Vol. 19 FEBRUARY 1946 No. 2

Instruments

THE MAGAZINE OF Measurement and Control

BAROMETERS
Mercurial

CONTROLLERS
Flow
Humidity
pH
Liquid Level
Pressure
Temperature
Vacuum

FLOW INSTRUMENTS
Controllers
Indicators
Integrators
Meters
Recorders

GAGES, RECORDING
Pressure
Temperature
Vacuum

HYDROMETERS

HYGROMETERS
Wet & Dry Bulb
Thermometers

LIQUID LEVEL
Controllers
Indicators
Recorders

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Absolute Pressure
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Grains, Tobacco,
Wood, Granular
Material

OIL TESTING
INSTRUMENTS

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Controlling
Indicating
Recording

PYROMETERS
Controlling
Indicating
Recording
Resistance
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RECORDERS
Electric
Flow
Humidity
pH
Hygrometer
Liquid Level
Pressure
Psychrometers
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Time-Operation
Vacuum

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Indicating
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Reducing
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Load changes upset control points
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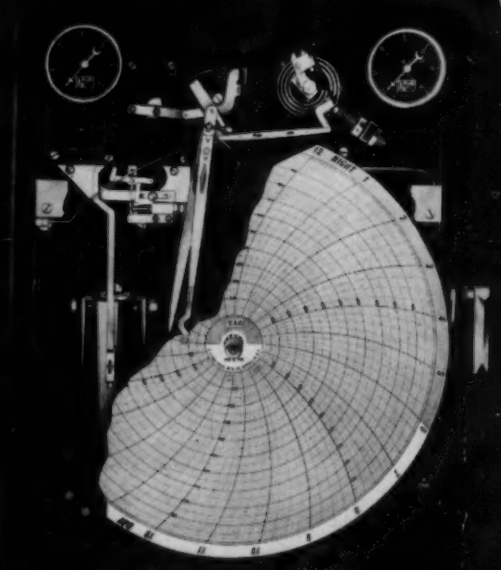

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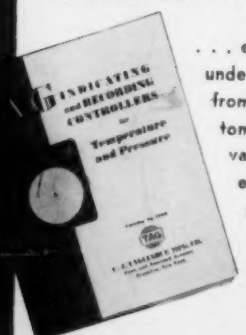

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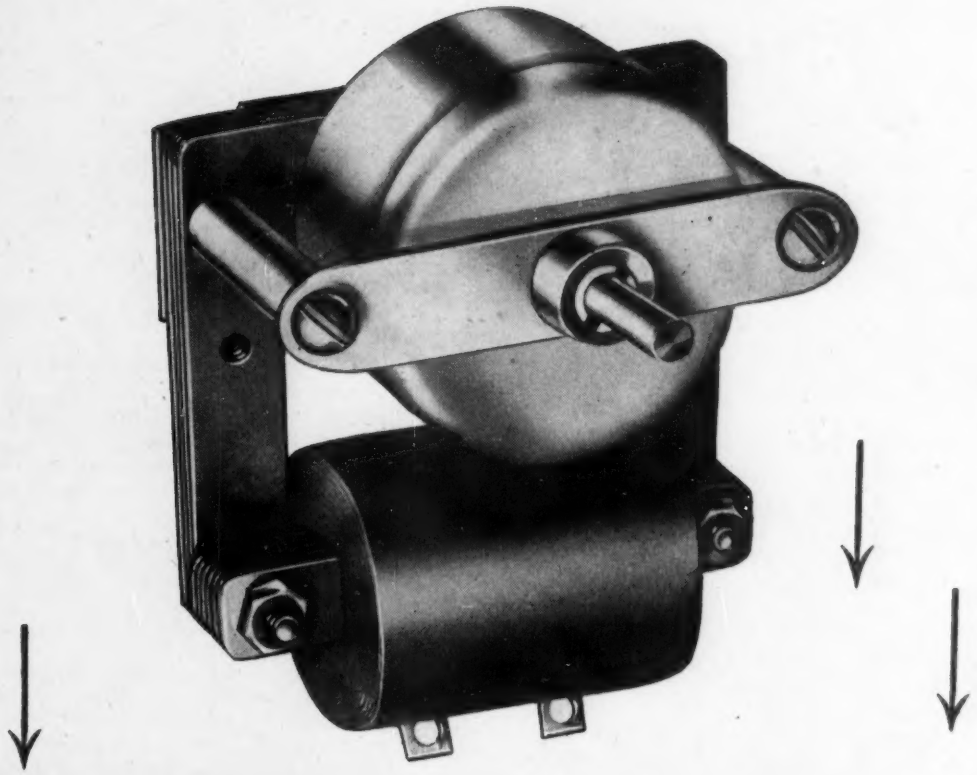

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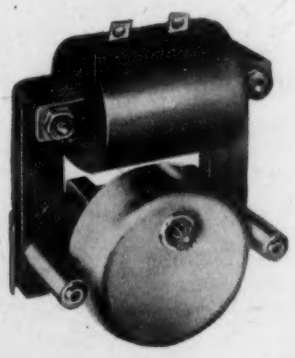

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SYNCHRONOUS MOTORS

WARREN TELECHRON COMPANY, ASHLAND, MASSACHUSETTS

Instruments
THE MAGAZINE OF
Measurement and Control

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Commonsense on Science Legislation

OF all discussions of proposed science-support laws, the one which comes nearest to the mature views of our wisest subscribers is the following.* We urge you to write to your Senators and Representatives (in your own words) supporting some or all the views.—MFB

(1) *National Science Foundation.* We believe that there should be created an authority (National Science Foundation) hereinafter called the Organization whose duty it would be to promote the fundamental and basic sciences in the interest of adequate national defense, of improved public health, of more effective use of our natural resources, and the increase of our scientific and industrial productivity in both quality and quantity.

(2) *Utilization of Existing Scientific Associations.* We believe that the Organization should make full use of the many recognized scientific, technical and engineering associations that have come into existence in this country during the past decades because we feel that the membership of those groups includes the more active and capable of our scientific and technical people.

(3) *Duty of the Organization.* We believe that the primary duty of the Organization should be to foster the development of the so-called natural sciences, that is, physics, chemistry, mathematics, medicine, and biology, to mention a few. We recognize the fact that a number of eminent people believe that the scope of a National Science Foundation should include not only the "natural sciences" but also the "social sciences" such as psychology, economics, sociology, political science, anthropology and history, for example. However, we believe that the objectives and technics of research and development in the social sciences are so different from those customary in the natural sciences that investigations in the former field should be supported by a separate authority set up for the purpose and which would be coördinate in every way with the Organization herein proposed. However, in the event that a separate authority is not feasible we strongly recommend that the support of social science research should be included among the duties of the Organization coördinate with that of the major divisions of the natural sciences.

(4) *Liaison Between Physical and Social Sciences.* We believe that an important function of the Organization should be the development of an effective liaison between those interested primarily in the natural sciences and those working in the social sciences.

(5) *Patent Policy.* We believe that the legislation covering the establishment of the proposed Organization should not attempt to change the present basic patent policy of the Government.

(6) *Selection of Governing Board.* We believe that it is of the utmost importance to have the Organization administered by men of the highest competence, completely independent of the influence of any special group. Although several types of organization could be set up to achieve this objective, it is our opinion that the work of the Organization should be administered by a Governing Board appointed by the President from a panel of scientific people recommended through existing scientific associations and that the Director of the Organization should be chosen by the Board and be responsible to it.

(7) *Compensation and Term of Office of Board Members.* We believe that the work of the Board would be of such magnitude, importance and complexity that the members should give it their full time and should be paid accordingly. It is our opinion that the Board should be a continuing Board and that the normal term of office of individual members should be not less than six years. The Governing Board should be authorized to enlist the aid of qualified scientific advisors and be responsible for their remuneration.

(8) *Administration of Funds.* We believe that the Board should be entrusted with the administration of all funds appropriated to the Organization and with the award of contracts for research work, development work, purchase of equipment, modification of existing facilities or creation of new, and for such other purposes as might be necessary to the prosecution of investigations sponsored by the Organization in either non-profit or industrial organizations.

(9) *Selection of Scientific Personnel and Projects.* We believe that the Organization should assist in the discovery and training of men and women possessing unusual abilities together with the special aptitudes necessary to creative scientific work in the fields of natural science research and that to these ends the Board should be empowered to award scholarships to selected students and grants-in-aid to individual science workers. We feel that the selection of scientific personnel and projects will tax the skill and vision of even the ablest Board and that on the wisdom of their choices will depend the long range success of the proposed effort to improve the scientific stature of our nation.

(10) *Collaboration with Government Representatives.* We believe that government representatives, Naval, Military and others, should cöoperate with the Board in advisory capacities only; that it should be the policy of the Board to seek advice of and to collaborate with such representatives; that there should be no ex-officio members on the Board and that no Board member should hold any other Government or private position either elective or appointive.

(11) *Publication Policy.* We believe that the Board should be responsible for publication of technical reports covering the results of researches under its sponsorship either in existing scientific and technical journals, in a publication of its own, or both. The Board should also be responsible for special publications designed to assist both the public and the Government to understand and apply effectively such developments in the fundamental or basic sciences as may arise from researches supported by the Organization.

(12) Finally, we believe that the powers vested in the Organization as well as its basic policies should be such as to assist the normal scientific activities of either individuals or organizations. We wish strongly to emphasize our conviction that the proposed Organization could best serve the nation by assisting in the creation of an environment favorable to independent thought and creative activity in the fields of both fundamental science and basic technological development, and by aiding the body politic to assimilate and benefit from the results of scientific achievements, whatever their origin.

*Prepared for the Physical Society of Pittsburgh (oldest local group of physicists) by A. G. Worthing, H. G. Botset, F. H. Brace, L. O. Grondahl and F. Seitz; adopted (after long discussions at the 199th and 200th Meetings) by a vote of 45 to 2.

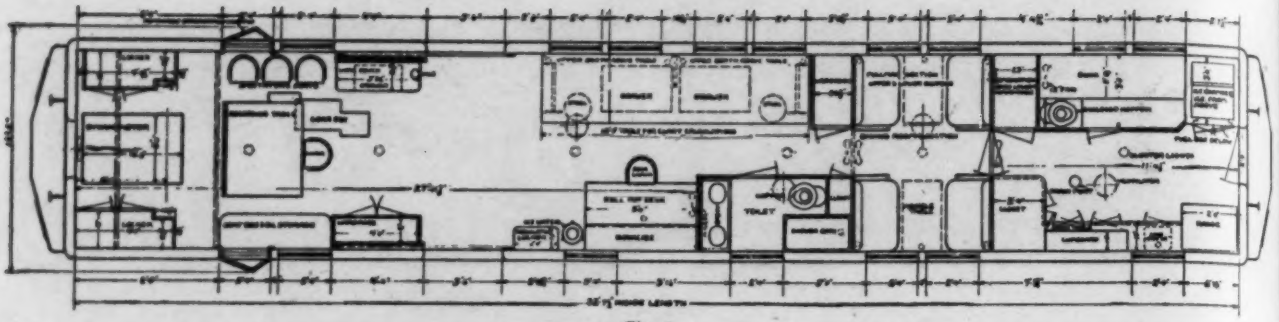


Fig. 1

The New York Central Railroad Company's DYNAMOMETER TEST CAR

By W. F. COLLINS, Engineer of Tests, New York Central System

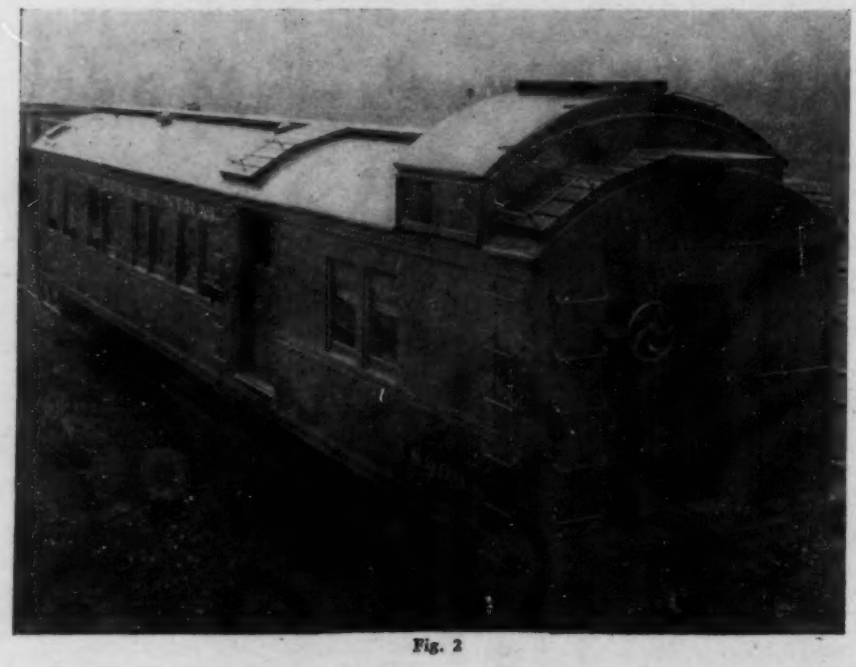


Fig. 2

General

IN brief, a railroad dynamometer car is a car fitted with a traction dynamometer (and other recording and indicating instruments), generally placed next to the locomotive and used to determine its performance in handling a train.

A traction dynamometer is a test apparatus for measuring the force or the power exerted by the locomotive. The force is commonly called the drawbar pull; and the power exerted is called the drawbar or dynamometer horsepower. Most readers of *Instruments* no doubt remember performing "the dynamometer experiment" in "Mech Lab" and remember taking data on forces, times and lever-lengths or distances, using relatively small laboratory apparatus. The physical principles involved in railroad locomotive dynamemetry are the same, but the measured magnitudes are relatively huge. The New York Central System's

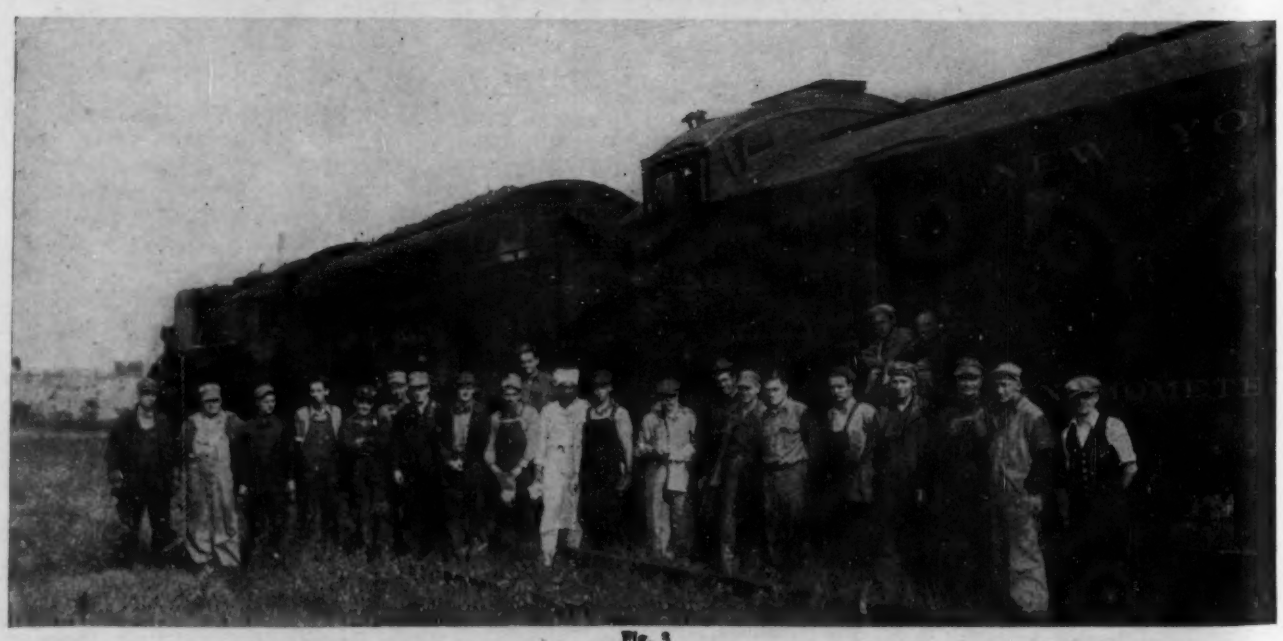


Fig. 3

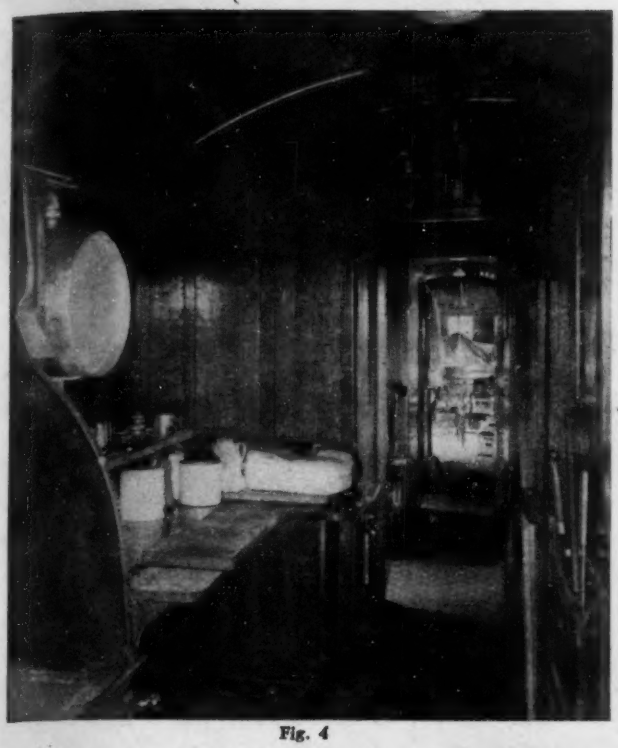


Fig. 4

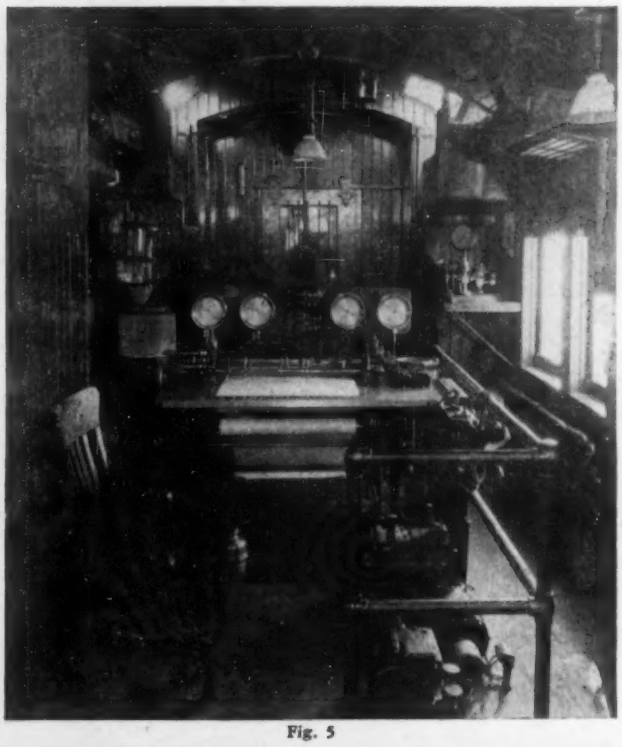


Fig. 5

Railroad Dynamometer Car, X-8006, is 54'10" long by 8'8" wide; and weighs sixty-two tons. It was built in 1923 by the New York Central shops and cost about $50,000 at that time. The cost of the Dynamometer apparatus was about $20,000.

Fig. 1 is a floor plan of this car, showing its general layout or arrangement. The Dynamometer apparatus is located at one end of the car and occupies altogether about 25% of the floor area. In addition to housing this apparatus, the car provides accommodations for the crew; sleeping quarters for seven, wardrobe facilities, lockers, bath, kitchen, etc. The office section is in the center of the car; and the kitchen and sleeping quarters are at the end opposite the Dynamometer.

The photograph, Fig. 2, is an exterior view of Dynamometer Car X-8006; and Fig. 3 is a group photograph taken before or after a test, this particular group including the test crew, the train crew and the locomotive crew.

Fig. 4 is a photograph taken from the kitchen end of the car. It shows the kitchen section; and through the door can be seen a small portion of the sleeping quarters, beyond which can be seen a glimpse of the office section. The Porter's quarters are at the right of the aisle and the kitchen.

Fig. 5 is a photograph taken in the same direction but closer to the office section and to the Dynamometer apparatus end of the car: it shows clearly the Dynamometer recording table at which the Dynamometer Operator is stationed during a test.

Fig. 6 is a view of the office section taken from the opposite direction: toward the sleeping quarters and

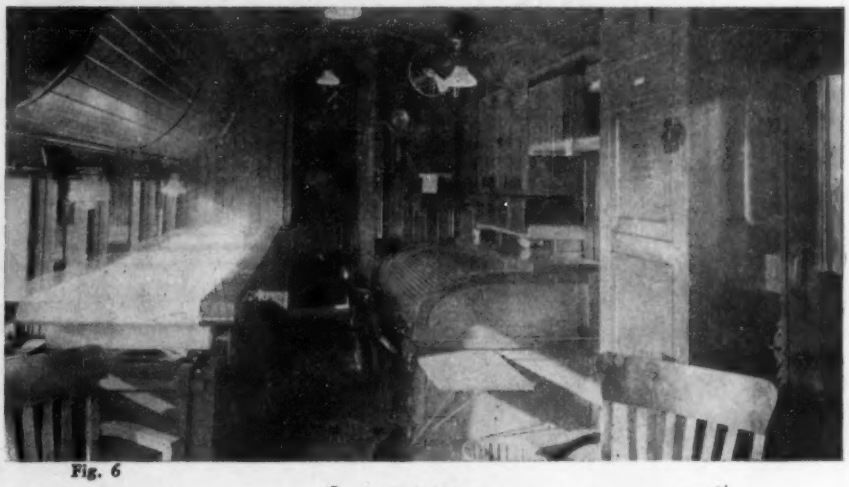


Fig. 6

Fig. 7

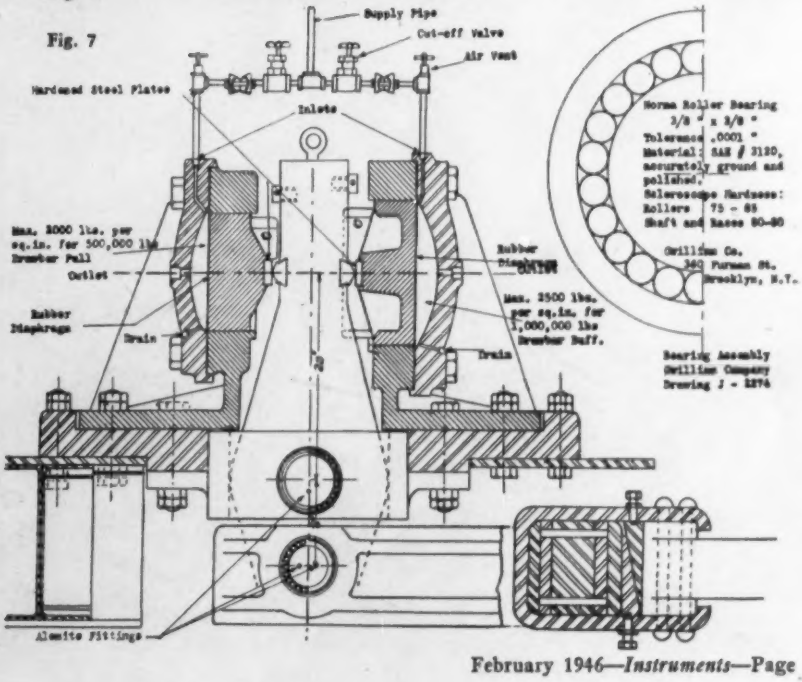


Fig. 8

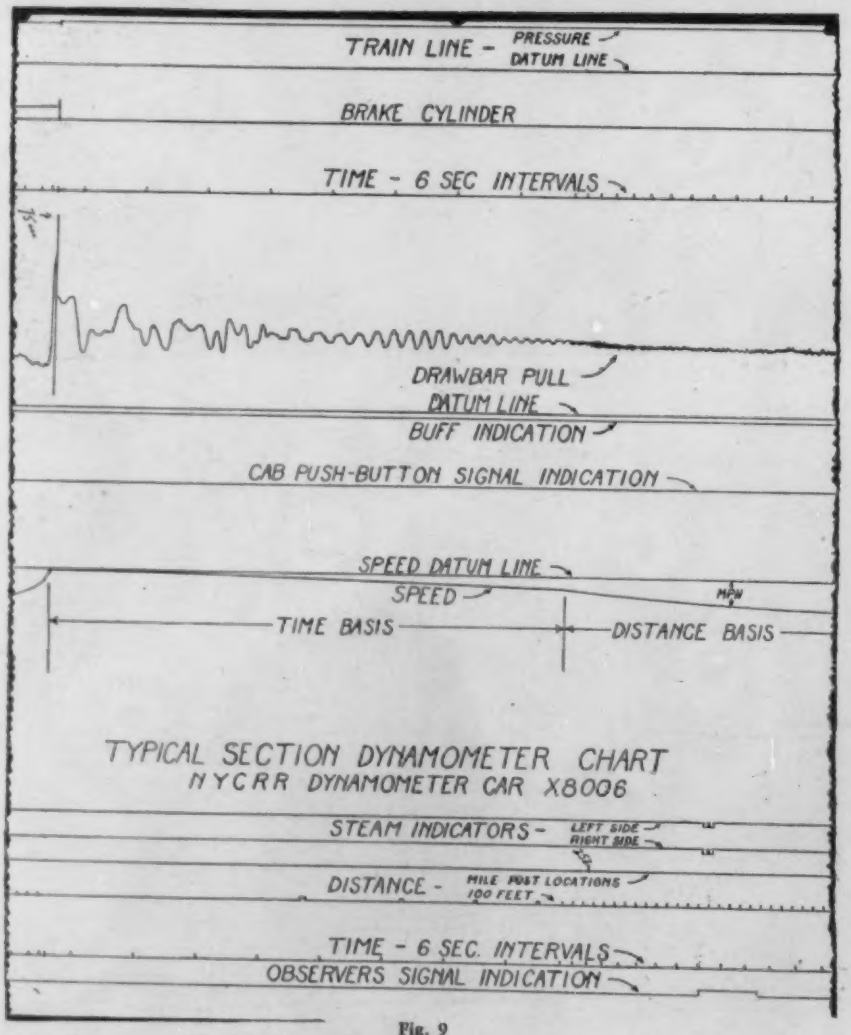


Fig. 9

kitchen. It shows at the left the chart table or computing table for studying and working up data from Dynamometer charts. Over this long table are two upper berths.

Dynamometer Apparatus

The Dynamometer apparatus attached to the Dynamometer weighing head is shown in Fig. 7. The drawing shows a cross-section of the weighing head, the coupler yoke and part of the coupler shank. The Dynamometer weighing head operates on a hydraulic principle with a diaphragm. The pull or buff from the drawbar is imposed without loss through the diaphragm to the liquid mixture in the weighing head.

Maximum sensitiveness for weighing apparatus has been attained by the following important design and construction factors:

(1) High fluid pressures are used.

(2) Inertia effects have been overcome by minimizing weights of parts.

(3) Use of every means of overcoming friction and limiting the movement of parts. The piston movement on maximum drawbar pull is about 0.006".

The large cylinder or buff is capable of taking shocks up to 1,250,000 lbs. while the smaller cylinder is capable of taking a drawbar pull or load up to 500,000 lbs.

The Dynamometer apparatus was built and installed by the Burr Company of Champaign, Illinois, but is now being handled by the Baldwin Locomotive Company.

Chronograph Table Unit

The Dynamometer recording table which was shown in Fig. 5 is shown close-up in Fig. 8 which was taken during a test, so that the moving paper chart is seen clearly, as well as the sixteen pens.

From the number of pens it may be inferred that the table unit comprises a number of instruments. One is a speedometer which indicates the car speed and also records it on the chart. Another important instrument is an integrator which automatically measures and records every six square inches under the drawbar pull curve; and this area is automatically totalized on an electric counter.

The time record of any portion of a test is produced by marking six-second intervals automatically on the chart. Alternatively, the distance record is produced by automatically marking every 100-foot interval traveled by the car.

Automatic records of train line and brake cylinder pressures, boiler steam pressure, and manual indications for location of mile-post, locomotive throttle location, indicator cards, coal fired in 100-lb. lots, and also other items that may be desired in connection with test work, are maintained.

For special items, extra circuits and counters are provided; and all these electric circuits are carried from the

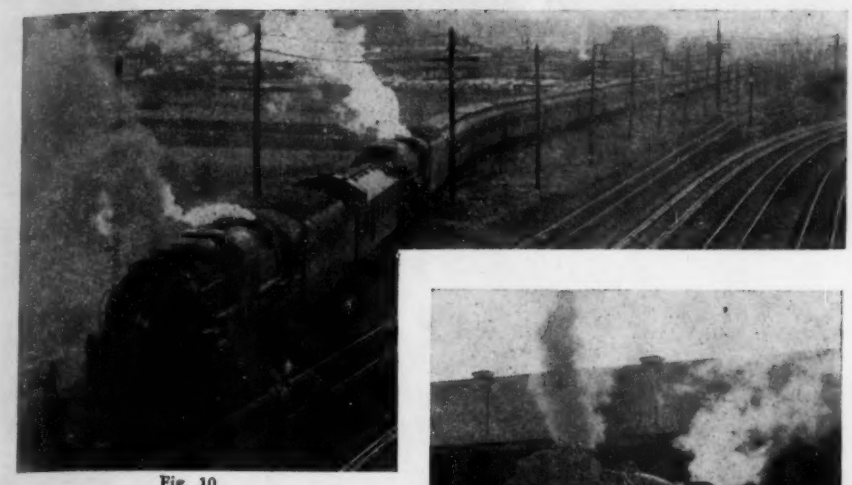


Fig. 10

car to the locomotive by a special cable which includes telephone connections and signal for the observers and which is used to record their readings simultaneously either to the front or rear locomotive.

The recording paper is 24" wide and Fig. 9 shows a typical section, reduced to 5½" wide. This paper can be driven on a *time basis* by a constant-speed electric motor which is connected to a variable-speed transmission case which provides for selection of three speeds of paper, namely 4", 16" and 60" per minute. The first half of the chart in Fig. 9 (left-hand portion) shows the record taken on a time basis.

The paper chart can also be driven on a *distance basis* from an axle drive unit or mechanism on the car axle and the "transmission unit" provides for selection of three speeds of paper travel, namely 1/16", ¼" and 1" per 100 ft. of car travel. The distance basis is the usual arrangement during most road tests. The second half of the chart on Fig. 9 (right-hand) shows the record taken on the distance basis.

The crew operating the Dynamometer car during a test consists of the Dynamometer Engineer, his assistant, a Dynamometer Operator, eleven apprentices, a mile-post recorder, an engineman, a fireman, two coal passers and a chef from the Dining Service.

Six of the eleven apprentices are Special Apprentices—men who have a degree from a technical school—and five are regular shop craft apprentices. They are selected from the shop and enginehouse forces of the Motive Power and Rolling Stock Departments.

Purpose of Dynamometer Car

The purpose of the Dynamometer Car is, briefly, to determine:

(1) Car resistance of passenger or freight cars.

(2) Train loading and tonnage ratings.

(3) Acceleration tests of trains.

(4) Brake tests of trains.

(5) Locomotive performance or efficiency tests.

(6) Locomotive capacity or pull-speed tests.

Fig. 10 shows the test train for pull speed test in passenger service, on a siding. Fig. 11 is a close-up of the test locomotive Dynamometer Car and helper locomotive. The helper locomotive regulates the train speed while the test locomotive is operated under constant or fixed test conditions, which will be explained later.

Fig. 12 is a photograph of the test locomotive, showing the steam indicator card apparatus and the observer's box over the pilot beam.

Fig. 13 shows the pressure gages on the running board where the observer records the boiler steam pressure at the dome, superheater header and exhaust passages.

Fig. 14 shows the cab observer with telephone connection to the Dynamom-

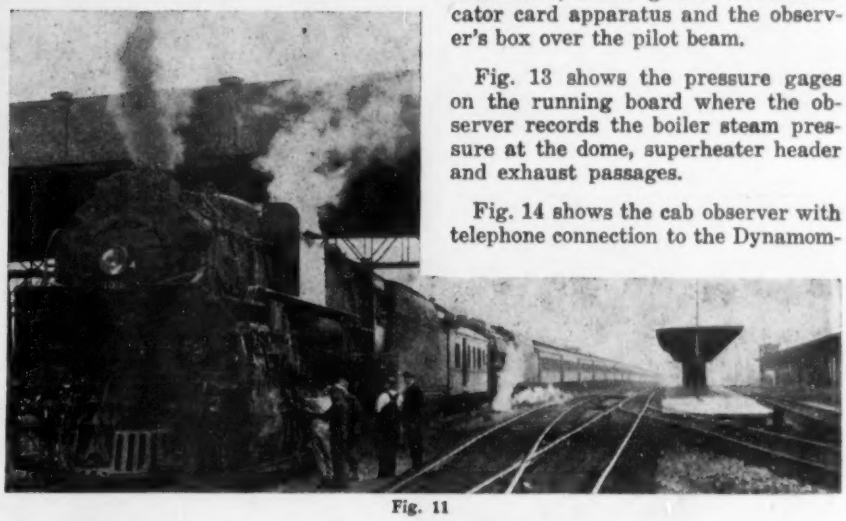


Fig. 11

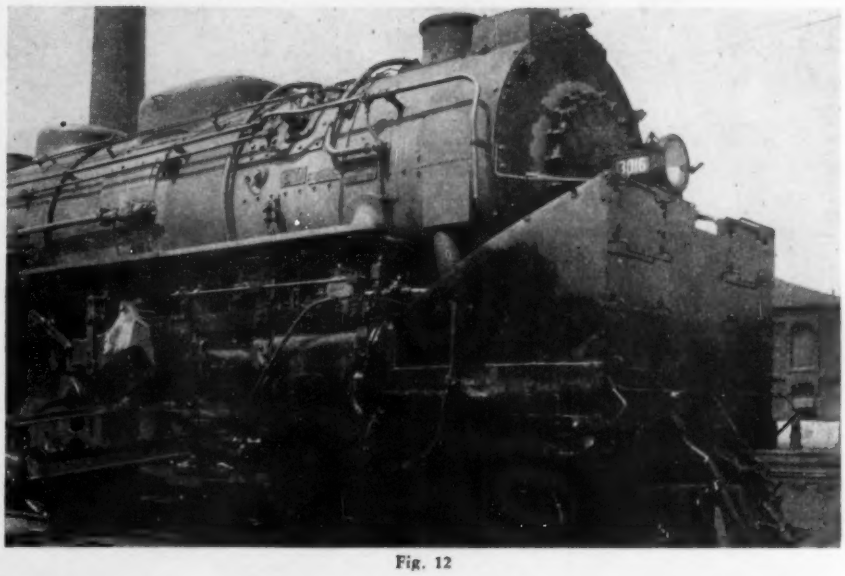


Fig. 12

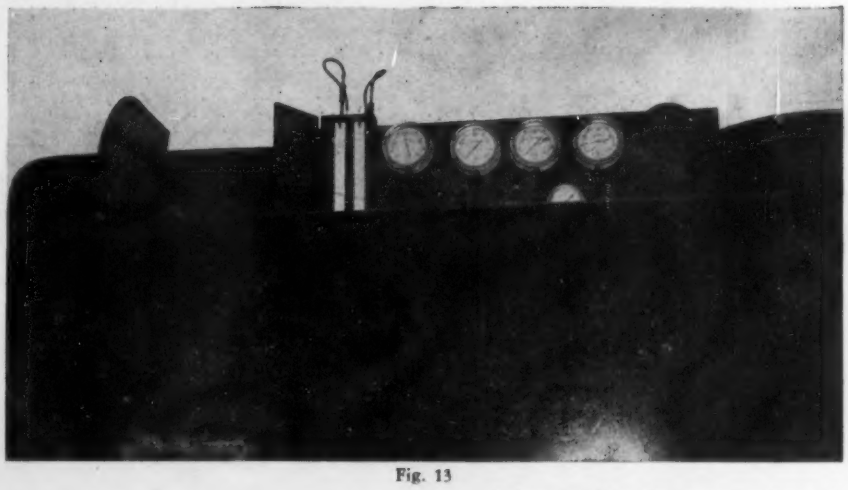


Fig. 13

Fig. 14

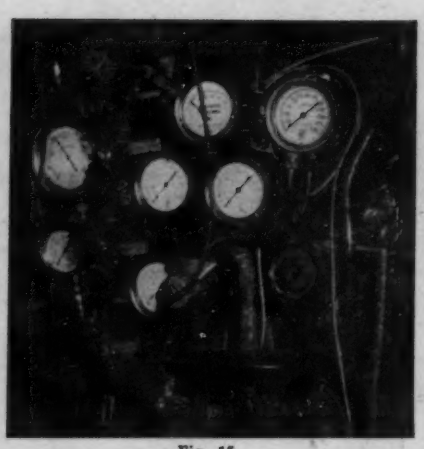


Fig. 15

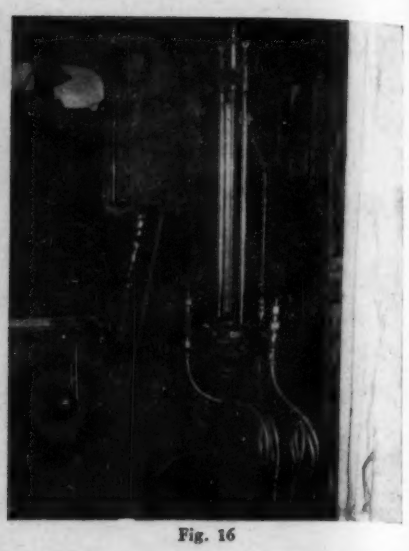


Fig. 16

Fig. 17

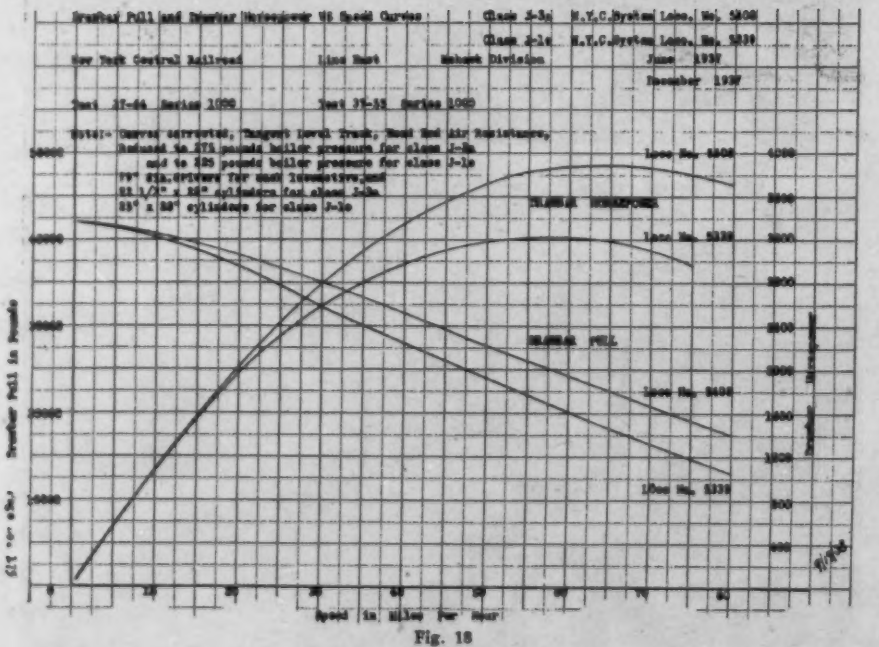


Fig. 18

eter Car over which the observer sends in his readings and receives his instructions from the Dynamometer Operator.

Fig. 15 shows the test gages in the cab, which indicate steam pressures of the auxiliary boiler apparatus, such as stoker, feed water heater pump, etc.

Fig. 16 shows the indicating manometer of the venturi water meter, which indicates the rate of flow of feed water to the boiler.

Fig. 17 shows the temperature observer located in the Dynamometer Car. The potentiometers indicate the temperature of combustion in the firebox, smokebox, and also the temperature of the superheated steam to, and of the exhaust steam from, the main locomotive cylinders.

Dynamometer Tests

In the *Car Resistance Tests*, the principal data obtained are the drawbar pull and speed, from which the car resistance is computed on the basis of pounds of car resistance per ton of weight of the car. The trains are made up with cars of specific weights or close average, such as 20-ton cars, 40-ton cars, 60-ton cars or 70-ton cars.

In the *Performance Tests*, all coal and water consumed are accurately measured and then the coal and water rates are computed per cylinder indicated and Dynamometer horsepower at a specific speed.

In the *Pull-speed Tests*, the object is to determine the maximum indicated horsepower or the maximum drawbar pull and Dynamometer horsepower for a specific cut-off of the engine cylinders and at a specific locomotive or train speed.

Fig. 18 shows the comparison of the drawbar pull and Dynamometer horsepower for a passenger locomotive tested in 1937 as compared with an earlier design. The difference in these curves represents the improvement on performance of the later design locomotive that has been accomplished.

A New Servomechanism Theory: the Synthesis of Automatic-control Systems

By W. C. ROBINETTE, South Pasadena, Calif.

Introduction

ONE year after Pearl Harbor the present writer was invited by the editor of *Instruments*, who had learned of some developments by our laboratories, to send him: (1) technical articles on certain new methods of automatic control and (2) brief descriptions of certain new instruments. These "invitations," however, were surrounded by severe conditions. Firstly, censorship had to be observed because some of our new methods (and the devices in which they were embodied) were used for important military purposes. Secondly, his own editorial policy stipulated that a technical article describing any new theory must be free from commercialism: it must not be merely a description of new commercial products, because such commercial announcements belong under "New Instruments" in the back of the magazine and not as a main feature, even though the Armed Forces had adopted the new devices and had acclaimed their superior performance.

For three years, consequently, the combination of rigid military censorship and equally rigid editorial standards postponed the making of certain disclosures believed to be potential contributions to the advancement of the art of Automatic Control to which *Instruments* readers are dedicated.

Recently, simultaneously with a partial lifting of military censorship, the "invitation" was renewed—as well as the conditions.

Fortunately, the particular restrictions of military secrecy which have not yet been lifted coincide almost exactly with our most cherished "commercials." That is to say, secrecy must still be maintained as to the circuits and operating principles of certain electronic components designed and manufactured by our company for the Armed Forces.

It is equally fortunate that the kind of description of servomechanism theory which we are at last permitted to disclose is the non-commercial kind which *Instruments* specified.

But perhaps the most fortunate thing about this long delay—as far as the readers are concerned—is that it has enabled the writer to develop a novel theory of servomechanisms by actually trying out a long series of applications: numerous forms of practical combinations of electronic, electromagnetic and mechanical components.

Empirical Origin of the Theory

In short, it was the actual study of servomechanisms in actual practice that gave birth to the first glimmer of a new theory. Then the new-born theory was tried out on more and more difficult problems of automatic control (especially after Pearl Harbor). Trial-and-error procedures dictated the exact characteristics which the several physical components should possess. Accordingly, various components were refined or re-designed as the growing theory dictated. Then further practice led to final development of the theory.

Before stating our theory, it is useful to define a Perfect Servomechanism as a regenerative automatic-control system in which the instantaneous error of the load corrects the dynamic response in such a manner as to decrease this error to the vanishing point in spite of changes in conditions to which the load may be subjected.

In short, a servomechanism is a synthetic individual capable of ratiocination, possessing the muscles necessary to carry out the program indicated by such ratiocination. The creation of such synthetic individuals has long stimulated human imaginations, as witness Mary Shelley's story of Frankenstein's "monster"; and Karel Capek's play, "Rossom's Universal Robots." Despite the tragic endings of all such legends, modern science has turned with enthusiasm to the creation of such synthetic individuals. The resulting mechanisms have had a terrific impact upon our industrial civilization. The United Nations' proficiency in this art hastened the defeat of the Powers of Darkness, since untiring servomechanisms controlled with miraculous accuracy our engines of attack and destruction, after other untiring servomechanisms had made possible the large-scale production of all war goods from uniforms to uranium by automatic processes requiring practically no manual labor.

In the past, the synthesis of servomechanisms has required elaborate manipulation of highly complicated and esoteric theoretical and mathematical relationships. It may be said that fewer than three dozen scientists and engineers in all the world are capable of synthesizing basically new servomechanisms. The rest of the engineering and scientific world must empirically develop synthetic individuals by a laborious trial-and-error process in the laboratory. This synthesis is costly: the time and money required are proportionate to the accuracy and sensitivity which the servomechanism must display. It would not be exaggerating to say that the evolution of certain servomechanisms has required years of time and millions of dollars.

We freely admit that our new theory of servomechanism follows this empirical procedure. It was the attainment of certain performance characteristics in our laboratory which led to the design of servomechanisms with the entire range of the dynamic and static variables adjustable by simple mechanical manipulations. This *adjustability* is the basis of the theory.

Brief Statement of the Theory

Given servomechanism components with the proper characteristics of dynamic range and adjustability, any mechanic can apply such components to any of a large class of control problems by following simple instructions; and the result will combine satisfactory accuracy with unfailing stability.

Because our theory is based on adjustability, any person of moderate arithmetical ability and a master of "screwdriver mechanics" can apply it and synthesize his own servomechanical control system; or, as the uninitiated layman would express it, "build his own robot." No knowledge is required of differential or integral calculus, differential equations, Laplacian transforms, sinusoidal functions, vector analysis, electronic theories, inverse feedback amplifiers, electromechanical circuit equivalents, etc., etc.

Specific Practical Nature of the Theory

The foregoing assertions will probably engender heated discussion, since scientists and engineers accustomed to arduous wrestling with elusive and difficult mathematical theories may find many of their dogmas by-passed.

We wish to point out, therefore, that our theory is not general but specific; and that it is not mathematical but practical. To elucidate this point and classify our theory beyond possibility of misunderstanding, we now define the four classes of servomechanism theories.

A general theory is one that applies to all types of servomechanism components, namely, mechanical, electrical, electronic, hydraulic and pneumatic; also to all ranges or sizes; and of course to all makes. Thus we have the first two classes:

(1) A *general mathematical* theory is one that applies as stated above and that is presented in mathematical language. Among the examples in the literature are the wondrously conceived and brilliantly presented equations of Nicholas Minorsky, H. L. Hazen, L. A. MacColl, Gordon Brown and D. G. Prinz—to mention only a few.

(2) A *general practical* theory is one that applies as stated above and that is presented in non-mathematical language so that it may be applied by any person of moderate arithmetical ability to synthesize his own control system from components of all types. The only example in the literature is the concluding section* in Chapter III of M. F. Behar's book on "Fundamentals of Instrumentation."

A specific theory is one that applies specifically to *one* type or make of servomechanism components — or to more than one but *not* to *all* types and ranges and makes. Thus we have the third and fourth classes:

(3) A *specific mathematical* theory is one that applies as stated above and that is presented in mathematical language. There are a great many examples in the scientific literature of the radio, electronics and wire-communications fields.

(4) A *specific practical* theory is one that applies as stated above and that is presented in non-mathematical language so that any person of moderate arithmetical ability can synthesize his own control system from the specific components covered by the theory. The only example is the one now disclosed for the first time in the easily-understood instructions which follow. It applies specifically to the *fully-adjustable* components known as "Motron" and is therefore to be known as the Motron Theory.*

*This will be reprinted in the next issue of *Instruments*.—EDITOR.

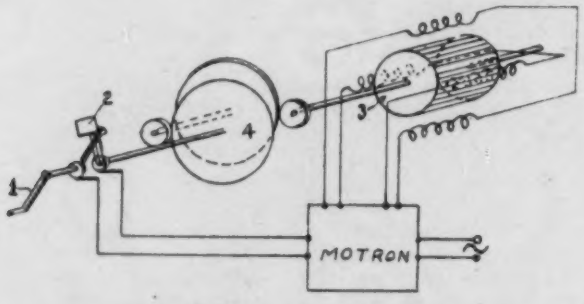
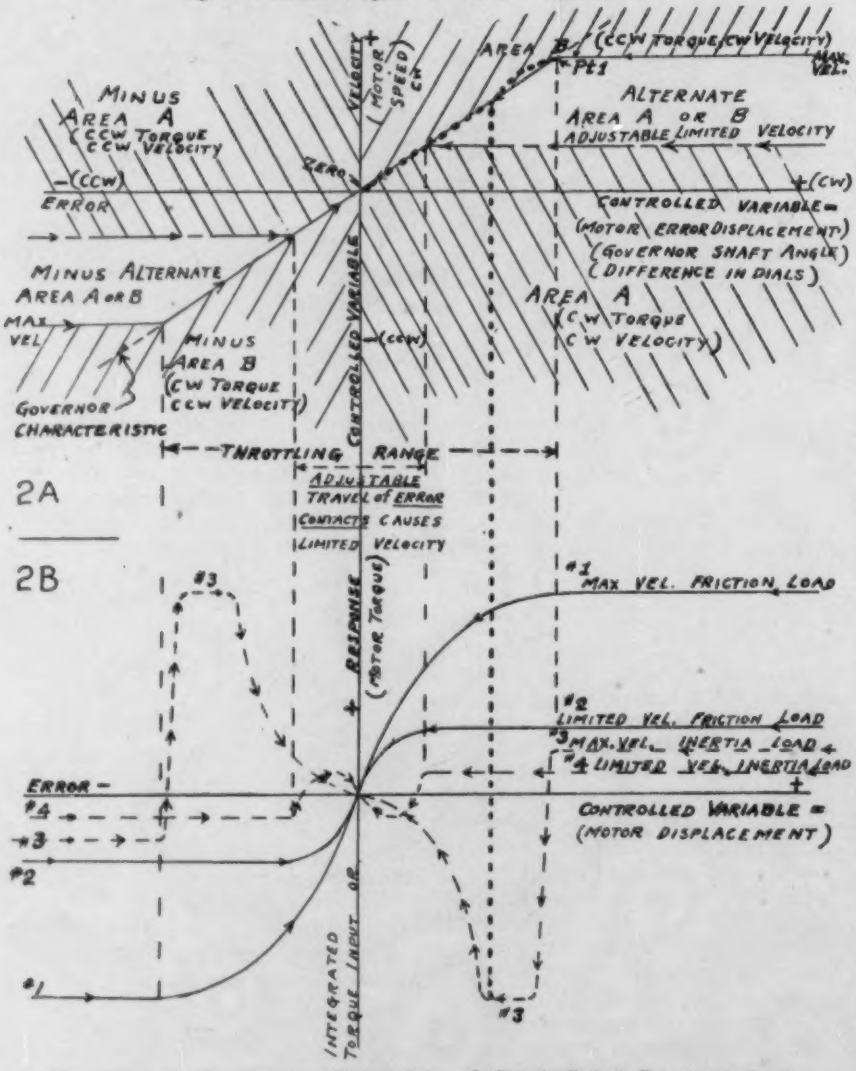


Fig. 1. Schematic diagram of "Genus I" Motron Servo.


MINUS AREA A (CCW TORQUE CCW VELOCITY)
AREA B (CCW TORQUE CW VELOCITY)
MAX. VEL.
Pt 1
ALTERNATE AREA A OR B ADJUSTABLE LIMITED VELOCITY
VELOCITY (MOTOR SPEED) CW
ZERO
-(CCW)
+(CW)
ERROR
CONTROLLED VARIABLE = (MOTOR \ ERROR DISPLACEMENT) (GOVERNOR SHAFT ANGLE) (DIFFERENCE IN DIALS)
MINUS ALTERNATE AREA A OR B
MAX VEL
MINUS AREA B (CW TORQUE CCW VELOCITY)
AREA A (CW TORQUE CW VELOCITY)
GOVERNOR CHARACTERISTIC
THROTTLING RANGE
ADJUSTABLE TRAVEL of ERROR CONTACTS CAUSES LIMITED VELOCITY
2A
2B
#1 MAX VEL. FRICTION LOAD
#2 LIMITED VEL. FRICTION LOAD
#3 MAX. VEL. INERTIA LOAD
#4 LIMITED VEL. INERTIA LOAD
RESPONSE (MOTOR TORQUE)
ERROR
CONTROLLED VARIABLE = (MOTOR DISPLACEMENT)
INTEGRATED TORQUE INPUT OR

Figs. 2A and 2B. Response Characteristics of Velocity-limited Error-proportional "Motron" Servomechanisms.

It is not claimed that all existing types of complete servomechanisms may be duplicated or synthesized directly in this manner by selecting electronic, electrical and mechanical components which were developed in our laboratory. Nor is it claimed that extremely high performance may be obtained in all cases. However, if the individual problem does *not* require such excessive speed of response that special low-inertia motors are required to minimize the dynamic lag error; or if the time constant of the system is *not very long* (*e.g.*, a *small* fire under a *large* kettle would require a *long* time to reach equilibrium temperature after a change in the height of the flame; this is a "long time-constant" system) then an *acceptable solution* (defined in the next paragraph) could be provided by a set of components, or a system, designated as "Genus II Motron servo, Type 61A." In this designation, the term "Genus II" refers to a Motron servo technically only applicable to high inertia systems with short to medium time-constant response. (Type 61A" will be described later as an illustrative example.) *These devices are not commercially available at the present time.*

By an acceptable solution is meant: (1) that the static sensitivity (*i.e.*, smallest disturbing error to which the servo will cause corrective action) will be 0.14% to 0.02% under ordinary operations; and (2) that simple screwdriver adjustments are provided to prevent "hunting" and maintain "dead-beat" stability. ("Hunting" is a wild forced oscillation about the true operating point, in which the servomotor overcorrects and forces false velocity response into the controlled mechanism. Such hunting may result in serious damage. "Dead-beat" operation is the smooth and gentle approach to a resting place in minimum time without overshooting the mark.)

*"Motron" is a registered trademark for equipment, manufactured by the company with which the writer is associated, for the electronic control of induction motors. The word is derived from the first syllable of Motor and the last syllable of Electron. The control is completely electronic in its operation. No relay or circuit-breaking device is included, since the reversing action is accomplished by change in electron flow in two small high-vacuum tubes. The induction motors used are the conventional squirrel-cage rotor type with two-phase windings. The control circuits are at sparkless levels of microamperes. The methods of control and apparatus herein described or referred to have been developed in this company's laboratories and are protected by the usual patent applications, etc. The system is officially designated as Motron Velocity-limited, Error-proportional Servomechanism, featuring practical infinite gain, or generally as Motron.

Characteristics of the System Selected As First Example

This system has the following characteristics (see Figs. 1 and 2):

(A) The torque-error constant of the servo tends to closely approach "practical infinity." (Full motor torque will be caused by an infinitely small error.)

(B) Because of the fact that the torque-error curve is infinitely steep (within the limits of practicality and design finesse noted above) the only forces involved in controlling the torque-error curve are infinitely small.

(C) If a given system load has sufficient inductance or inertia so that the maximum motor acceleration is too small, or the coupling between motor and load is too loose to prevent time phase shift of the feedback vector (*i.e.*, motion of the inside feedback dial), severe hunting of large amplitude and low frequency may occur. However, if the servomotor is governor-controlled so that the *speed* is directly proportional to the error (instead of having the *torque* proportional to the error as is common practice) system stability is no longer tied to load inertia and inductance. The load may be removed completely, or the relative balance between inductance and resistance may be changed without substantially affecting the servo. To our knowledge no other servo possesses this characteristic of stable system performance independent of load inertia and load friction. This is known as a Motron Genus II servo and is applicable to high-inertia, short-to-medium time-constant mechanism and processes.

(D) Ability to provide for the control of an induction motor with very small amounts of power, much smaller than heretofore considered practicable. Therefore only small electronic equipment is required.

Characteristics A through D are demonstrable. The theoretical relationships covering the desirability of infinite gain are covered in certain references to prior art now held secret. Further discussions of the theoretical desirability of infinite gain should be postponed.

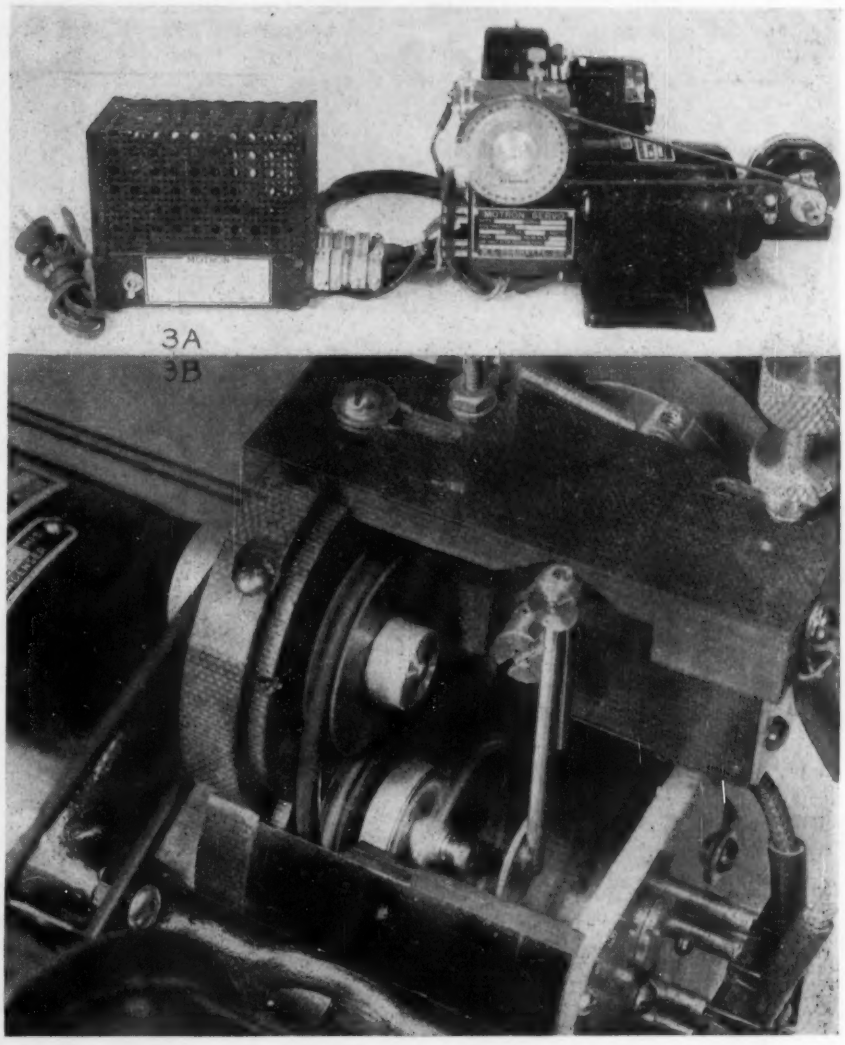
Characteristic C is of the utmost importance to the design engineer of servomechanisms, since it enables the engineer to design a servo controller in the same objective straightforward manner that is possible in other engineering problems. This characteristic C makes possible so important a forward step in servomechanism practice that we recommend the re-examination of all previously-designed servomechanisms to evaluate their possible performances in terms of *velocity-limited error-proportional* operation with practically infinite gain.

The distinctive characteristic of this system is that the velocity of translation of the controlled variable is proportional to the error, provided only that certain relationships between system kinetic energy and rate of energy input be maintained. (Contrast this relationship with the conventional torque proportional to error system.) Specifically, a governor is associated with the controlled variable in such a manner that there is a unique governor deflection for any condition of speed and direction of translation of the controlled variable. This governor is in the case on the rear of the motor to the right of the fan. See Fig. 3. The error of the variable is the position of the control contact that coöperates with the governor, which is the difference in angular setting between inside and outside dials. Specifically, then, a given error in the controlled variable sets up a given error-contact deflection position. The electronic controller then regulates energy input so as to establish the proper controlled variable and governor velocity for the given error. As the controlled variable approaches the zero-error position, a smaller and smaller governor velocity error is called for until at zero error the velocity is also zero and the controlled variable is at rest.

By suitably restricting the actual end travel of the error-contact position, the maximum velocity of the controlled variable translation can be limited to any desirable fraction of full-speed translation in spite of the instant condition of very large error. Thus the system can never "run away" faster than desired. This is a positive check against the occurrence of hunting and instability.

In the case of the Type 61A servo shown in Fig. 3, the governor error-contact is on an arm supported from the top of the governor case. The axle supporting this contact arm protrudes through the governor case and has a counterweight shaft with adjustable weights (screw thread nuts) to regulate the contact pressure on the governor. This counterweight may be seen between the governor case and the inside feedback dial. Thus the angular position of this counterweight shaft corresponds to a given velocity-setting on the governor. The limiting-velocity-stops on the top-side of the case, back of the inside dial, restrict the angular travel of this shaft.

The governor contact arm is operated by an error-eccentric of adjustable



Figs. 3A and 3B. General view and close-up of an experimental "Genus II Type 61A" Motron Servo.

eccentricity (inside the case). This error-eccentric is mounted on a shaft concentric with the two-dial axis, and the outer end of this shaft is driven from an epicycloidal differential gear (same as an old style Ford transmission) which applies the difference between the two dial settings as an angular rotation to the error-eccentric.

By changing the eccentricity of this eccentric, a given error (or difference between inside and outside dial readings) can be made to call for a wide range of governor speed settings. Thus if this eccentricity setting is large, a relatively small error can cause a relatively large motion of the governor contact and hence cause a high speed change of the motor; See line *a*, Fig. 4. If the eccentricity setting is small, it will require a relatively large error (difference in angular setting of the two dials) to cause a relatively small speed change; see line *b*, Fig. 4. If the eccentricity setting is small enough, the governor contact arm cannot move far enough to bring the system up to full speed even with maximum error. See line *c*, Fig. 4.

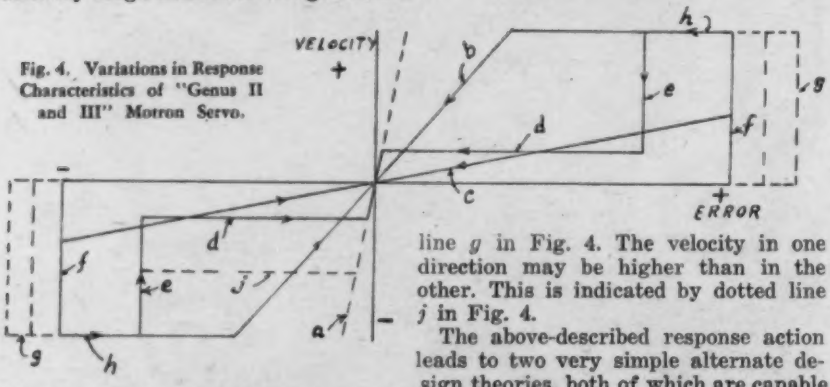


Fig. 4. Variations in Response Characteristics of "Genus II and III" Motron Servo.

Thus, increasing the eccentricity of the error eccentric will increase the speed of response, and decreasing the eccentricity will make the system sluggish. By increasing the eccentricity unreasonably (see line *a*, Fig. 4) the system sensitivity of response to small error may be made extremely high—far beyond the limiting sensitivity for stability. In this condition the system will hunt violently until the speed-limiting stops are restricted sufficiently to limit the maximum velocity to a value that will prevent hunting; see line *d*, Fig. 4. The system is then extremely sensitive—responsive to small errors—yet remains stable and dead-beat for large errors. However, the system may be undesirably sluggish in responding to relatively large errors if the lowered velocity response is not removed at a suitable large error; see line *e*, Fig. 4. This can be accomplished by placing suitable contacts in the governor electronic control circuit that will be actuated by the error eccentric. These contacts will remove the governor from control of the servomotor, thus allowing it to come up to full speed (see line *h*, Fig. 4) when the error is unduly large. (These contacts are not shown in Fig. 5.)

If the error (difference in the two dials) becomes too large, the error-eccentric will rotate far enough so that the governor contact will touch the governor. In this occurrence, the direction of rotation of the servo will reverse and approach the balance point from the opposite direction. This is indicated by the solid lines *f* in Fig. 4.

If it is necessary that a considerable range of error be required, an impulse-type stepping-switch may be operated by the error-eccentric contacts so that there is only the one balance point in spite of several revolutions of the error-eccentric. This is indicated by dotted line *g* in Fig. 4. The velocity in one direction may be higher than in the other. This is indicated by dotted line *j* in Fig. 4.

The above-described response action leads to two very simple alternate design theories, both of which are capable of resulting in satisfactory performance.

Theory "A"

Connect the servomotor to the load by any ratio gear drive that will give the approximate speed of operation desired (or higher by a reasonable percentage). Arrange a feedback linkage or gear from the controlled system to rotate either of the dials on the gear case. (In Fig. 3, a rubber belt from the worm gear shaft rotates the inside dial.) If the inside dial is used, pick a feedback gear ratio that will cause about 10 to 20 r.p.m. of dial at full speed of servo. If outside dial is used, the speed range at full servo speed should be approximately 20 to 40 r.p.m.

Lock the other dial in position, place the servo in operation, and observe the operation after a suitable warm-up period. If the system is sluggish, the eccentricity of the error-eccentric may be increased until the desired speed of response consistent with stability is obtained. If the stability is poor and there is overshooting and hunting, the eccentricity of the error-eccentric should be reduced until satisfactory stability is reached.

This design Alternate Theory "A" gives the best over-all balance speed of response, sensitivity and stability.

Theory "B"

In the event that no definite gear ratio can be chosen for the feedback dial, or if the feedback path is at unusably low energy and torque levels, or subject to process control response of indeterminate velocities and amounts, the following procedure is indicated:

Connect the servo to the system with any desirable gear ratio as before. Connect the feedback link mechanism either to the outside input dial or to the governor counterweight axle directly with any convenient ratio.

Place the system in operation and observe the response. If the system is sluggish, the feedback gear ratio must be increased so as to have a given motion of the feedback mechanism cause a larger governor arm displacement. This result is not likely to occur unless the feedback motion is very small and weak. If the system operation is unstable and tends to hunt and overshoot, the speed-limiting stops on the top-side of the case must be raised so as to limit the top speed to the extent necessary to prevent instability.

The speed-limiting stops should not be extended more than necessary to insure adequate process control, and the most critical direction of operation should be selected for the lowest speed. For instance, if the servo is used to cause a cutting tool to trace the outline of a pattern, it would be desirable to limit the velocity of cutting tool in toward the finished side so that the tool would approach slowly and carefully and not gouge into the finished surface. The velocity in the opposite direction could be as high as desired as long as satisfactory stability is maintained.

In this connection, a note that the governor electronic control circuit may be used to limit the travel of the system in either direction without destroying the ability of the error system to regain control once the error becomes less than the setting of the limit switch. Since the limit switch must carry only microamps, the most delicate machine elements may be protected by direct contact of small silver catwhisker wires, or other delicate contact-making parts.

Application Instructions: The Characteristic Curve

In order to make the application of the theory more lucid and to make the characteristic curve, Fig. 2, easily understandable, its application to a hypothetical servomechanism problem will be illustrated.

Let the servomotor be fastened to the load through suitable gear reduction so that the load (*i.e.*, the controlled variable) has a satisfactory rate of translation. This rate should be higher than the minimum acceptable rate by a substantial percentage to permit adequate control of operating speed.

Let the position of the load or controlled variable operate a suitable error-detection system that shall be coupled to the governor of the servomotor through a manually-adjustable control or differential to permit inserting the proper zero error or balance point, corresponding to the vertical zero line on the characteristic curve. Such a differential is included between the two dials on the side of the governor case on the rear of the motor; see Fig. 3. These from an epicycloidal differential gear inputs may be utilized if desired, or the governor control shaft may be utilized

directly if desired. (The outside dial is supported on small precision ball bearings of negligible friction. This input torque to control the servo is so small as to be difficult to measure. A triangular piece of dampened tissue paper 1¼" long by ½" wide at the base, used as a cantilever beam and rubbed against the flat surface of this outside dial, will transmit enough torque to control the servo in a non-hunting manner.)

The servomotor thus enters the throttling range at maximum *C-W* velocity. The inertia of the load and motor rotor turning at high speed carry the servo into Area B along the dotted line, which reverses the torque of the servo as shown by curve 3 of Fig. 2B. This reverse torque absorbs the kinetic energy of rotation of the servo and causes a decrease of velocity along the governor characteristic. As long as

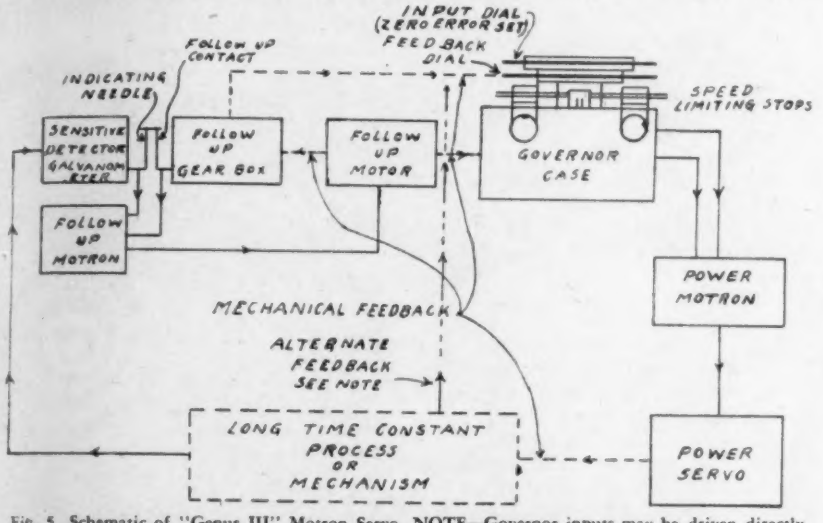


Fig. 5. Schematic of "Genus III" Motron Servo. NOTE—Governor inputs may be driven directly by long-time-constant process or mechanism if possible. This will eliminate follow-up system.

The error-detection system may be of any type that will provide enough torque to operate the outside dial or the governor axle and should have no backlash. The inside dial is mounted on a large needle bearing and should be rotated by the servo feedback mechanism or used as a manually-set dial to adjust the operating balance point as may be required. When the condition of stability is reached (as explained under Alternate Theories A or B) the servomotor will stop a medium-inertia load from high speed with the smooth dead-beat action illustrated in curve 3 of Fig. 2B, and a medium frictional load according to curve 1.

The operating method of this system will be understood by noting the cross-hatched areas of Fig. 2A. Every condition of load error and velocity will fall into plus or minus Area *A* or *B*, with the corresponding conditions of velocity and integrated torque associated with each area. Suppose that the above medium-inertia hypothetical servo load has an error and velocity relationship that will fall in Area *A* and that the velocity-limiting stops are fully retracted so that the motor can attain its maximum speed of synchronous rotation minus slip rotation, and that the error-eccentric is adjusted for optimum response. For control purposes this would allow the alternate area to be in the *A* area category and the servomotor could run at its maximum speed in the *C-W* direction until the error is small enough to allow the error-contact to intersect the governor characteristic at point 1, which is the limiting error for maximum velocity.

the instantaneous velocity-error coördinates are in area *B*, the servomotor torque remains negative and soaks up the kinetic energy, thus slowing the system down. If this reverse torque continues sufficiently to lower the velocity-error coördinates into area *A*, the servomotor torque will become *C-W* and increase the speed sufficiently to raise the speed up to the governor characteristic.

In this manner, the speed of the servo follows the governor characteristic down to smaller velocities and smaller errors until the zero error produces zero velocity. At this zero point the velocity is zero and there is no change of the error unless the controlled variable is disturbed. In this case the servomotor operates to restore the system to the zero point in exactly the same manner as above.

The servo approaches the balance point from the opposite direction in an analogous manner, using the negative values of all areas, speeds and torques.

If the system has a synthetic error-displacement rate fed into the outside governor control dial, the servo will attain a velocity that will exactly match the input displacement-error rate, but will lag the input error signal by the intercept on the governor characteristic required to maintain the given input error rate. This is a dynamic lag error.

The accuracy with which the balance or zero-velocity point is reached is high (as explained under "Characteristic A"). In the model shown the limiting slope for optimum response of the governor characteristic on the inside feedback dial is approximately 100 servomotor r.p.m. per degree of inside dial rotation. Since the gear ratio between the inside and outside dials is 1:2, the outside dial must rotate twice as fast as the inside dial, and in the opposite direction. Hence the limiting slope of the governor characteristic on the outside or input dial is approximately 50 r.p.m. per degree of rotation of the input dial. The above limits are for dead-beat (no overshooting) operation of a medium-inertia load and a feedback gear ratio of 2 motor turns = 1 turn of inside dial. The slope of the characteristic may be steepened appreciably if (a) a larger-powered Motron is used, or (b) a low-inertia servomotor is used or (c) it is allowable to have one or two overshoots, or (d) Design Alternate Theory "B" with large eccentricity and slow velocity is used.

Thus, for exceedingly fast, high-dynamic-accuracy type servos, a suitable design including all three of the above modifications (a), (b), (c) and Design Alternate "A" could produce a slope up to ten times the above rating, or say 500 r.p.m. per degree input or more and still maintain full speed operation with dead-beat response.

At this slope of the governor characteristic of 50 r.p.m. per degree of input dial the throttling range is ± 34° rotation of the input dial on 60-c.p.s. power supply and 1700-r.p.m. motor.

The worm gear reduction of the Model 61A shown is 60:1 with a no-load output speed of 29 r.p.m. With the motor output shaft geared 2:1 to the inside feedback dial, one turn of the outside or input dial will cause 1 turn output of the motor worm gear shaft.

The torque available at this shaft is in excess of the following values: Starting torque—28 inch-lbs.; Maximum load torque at 20 r.p.m.—35 inch-lbs.; Maximum load hp. (30% efficiency of worm gear)—1/100 hp.; Maximum safe load torque for long gear wear—13 inch-lbs.

(If the worm gear shaft is stopped forcibly when the motor is rotating at high speed, it is quite likely that the worm gear teeth will be sheared off. Protracted power-on operation in the stalled condition where the motor is exerting full starting torque on the load without motion of load will reduce gear life. It is therefore recommended that all obstructions or limits of travel of the load be protected with limit switches in the electronic leads of the governor.)

With the worm gear output shaft geared 2:1 with inside feedback dial so that one turn of outside input dial produces one turn of worm gear output shaft, the motor will position the dial to any selected degree marking within ± 0.25° on feedback dial. External disturbances or step-inputs of error will always be cancelled out within this ± 0.25°. Thus the motor will drive the feedback dial to within ± 100/(4×360) = ± 0.07% of its balance point. This corresponds to ± 0.14% on input dial and motor worm gear output shaft. If the worm gear shaft is geared to a rotating load through a 6-to-1 gear reduction, the load will rotate about 5 r.p.m. top speed and can be positioned to ± 0.02% or 4 minutes of arc of a given point.

This 0.14% sensitivity is the most unfavorable control condition likely to be met, since it assumes that the entire range of the controlled variable is in-

cluded within one turn of the worm gear shaft. If the input-dial drive cannot conveniently drive the input dial through the 34° throttling range directly, this throttling range may be lowered to a smaller value by increasing the eccentricity of the governor cam arm inside the governor case. This increases the slope of the governor characteristic as much as desired above the limiting 100 r.p.m. per degree for dead-beat operation. With this hypersensitive governor characteristic (Design Alternate Theory "B") the servo will be unstable and hunt violently unless the speed-limiting stops on the governor counterweight shaft (top-side of the governor case) are raised to restrict the speed. The percentage accuracy of static balance will increase directly as the slope of the governor characteristic increases. For instance, if the cam eccentricity is increased to steepen the governor characteristic slope to 500 r.p.m. per degree on the inside dial the full speed throttling range on the outside dial would be about ± 7°. However, the speed-limiting stops will have to be placed so as to limit the speed to about 40% of full speed to maintain dead-beat operation. Therefore the net usable throttling range is 40% of ± 7° or ± 3°, the top output speed is 40% of 29 or 12 r.p.m., and the sensitivity of balance will be ± 0.14/5; = ± 0.03% for one revolution total travel of worm gear shaft, or 0.005% for 6 turns of worm gear shaft, approximately.

After each change of cam drive eccentricity, it is necessary to re-adjust the side plate (notice slots for this purpose in Fig. 3A) carrying the two dial plates to center the balance point in the throttle range (*i.e.*, make the positive throttling range equal to the negative throttling range). The speed-limiting stops should then be re-adjusted if necessary.

It should be observed that the dead-beat and extremely sensitive servo action described above is insensitive to the inertia or friction character of the load, since the electronic regulator automatically detects whether the stopping operation is in Area *A* or Area *B* and acts to restore the velocity to the governor characteristic, thereby assuring dead-beat operation.

Theory for Synthesis of "High-performance" Servomechanism

Now we are ready to apply the theory to the solution of more difficult problems. It goes without saying that the requirements for the dynamic characteristics of some components are much more rigid. If this were a course of lectures, much of what has been explained would have to be repeated at this point. The reader is asked, therefore, to read again the preceding sections, or at least to glance through and satisfy himself that he understands the characteristics of the previously-described components and how they interact with the controlled variable.

In order to obtain the high grade of performance known as "high-performance Motron velocity-limited error-proportional" servomechanism action, three requirements must be satisfied:

1. The governor speed must be instantly proportional to the rate of motion of the controlled variable.

2. The position of the error-contact must be instantly proportional to the displacement of the controlled-variable motion.

3. The kinetic energy stored in the system at maximum system velocity must be absorbed completely by reverse motor torque in the half of the throttling range between full speed and zero speed so that the system arrives at the balance point with zero kinetic energy to prevent overshooting.

Condition No. 1 states that the speed of the governor shall be proportional to the rate of the controlled variable. In any servo control problem where the servomotor is fastened directly to a mechanism to control its position or operation directly from the torque supplied by the servomotor, the speed of the servomotor will be proportional to the rate of the controlled variable. Hence, for all direct-drive applications, the governor is fastened on the rear end bell of and driven by the servomotor, as is shown in Fig. 3.

For large power applications such as controlling the speed of large turbines, waterwheels, hydraulic steering servos, steam engines, etc., the servomotor may operate the throttle valve of the prime mover through a suitable reduction ratio. In this case the governor should be driven by the mechanism to be controlled, *i.e.*, turbine, waterwheel, steering motor, etc. (The servomotor blower manifold should not have a cutout for the governor housing in this case, or a sheet metal cover should be placed over the opening for the governor housing to prevent the servomotor overheating by reason of the cooling air being bypassed.)

In certain classes of large power applications, such as steam turbines driving generators, the output of which is subject to load regulation, it may be desirable to drive the governor directly from the final load condition, or from a small electric motor from the generator output so that the governor speed is directly proportional to the controlled variable.

In case speed control only is needed and reverse rotation is never required, the differential input speed to the governor from the cooling fan may be dispensed with by taking the internal belt drive off of the governor pulleys inside the governor case and locking the governor shroud to the inner shaft by means of the No. 4 hollow-head set screw provided. This increases the governor speed by 3.25:1 and spreads the governor throttling range from zero to full speed over 100° or more of the outside input dial.

A further simplification is possible in speed control applications in that no error input to the governor shaft is required. All that is necessary is to set the speed-limiting stop (not shown in Fig. 3) on the front of the governor housing to the desired speed. The electronic regulator will then maintain system speed on the desired setting.

If it is desired to synchronize a variable-speed system to another moving system, the difference in speed of the two systems may be obtained by means of a differential gear or differential synchro repeater motor, the output of which is transferred to the input dial as an error signal. This will alter the speed of the control system so as to cause it to remain in synchronism with the master system. The phase angle relationship of the controlled-variable system to the master may be set to any desired value by altering the dial reading of the inside dial and then locking it in place.

Note in this connection that the "Type 61 A Motron" servo may be used as a torque amplifier or remote-positioning system. If a synchro repeater motor is used to rotate the outside input dial to the differential and the servomotor rotates the other inside feedback dial the servomotor will act as a torque amplifier for the synchro motor. The feedback vibration of the servomotor, through the differential to the synchromotor, cancels out all bearing "stiction" and load on the synchro repeater. A synchromotor geared 36:1 to load will position the load within 1 minute of arc with the above set-up, provided that a low-inertia motor and high-performance Motron be used, and that all backlash in the error-measuring system be eliminated.

Conditions 1 and 2 above specify instant time response inputs to the governor system. This is not possible in a large class of servomechanism control problems, since a change in energy input by the servomotor may require several seconds or minutes for the error-measuring system to reflect the changed input conditions. Hence the governor does not represent the instantaneous velocity of the controlled variable and a slow hunting of the controlled variable may be expected. The period of this hunt will be several times the effective time-constant of the system. The amplitude of the hunt oscillation may be minimized by restricting the velocity of the servomotor by the adjustment of the velocity-limiting stops on the top side of the governor case. In addition, the displacement of the servo may be restricted to any desirable small error range by using suitable limit-switches in the electronic control circuit with the governor.

To illustrate this type of problem, suppose that the servomotor is to control the fluid pressure in a system requiring varying quantities of fluid through a long piping system, by the remote operation of a gate valve from

CLASSIFICATION

A "Genus I" Motron servo is applicable to low-inertia, very short time-constant systems.
A "Genus II" Motron servo (Type 61A) is applicable to high-inertia, short or medium time-constant systems.
A "Genus III" Motron servo is applicable to high-inertia, long time-constant systems.

a source of higher air pressure. The governor error shaft may be actuated by the pointer of the conventional Bourdon-tube pressure gage indicating the controlled pressure of the fluid. The pressure of the fluid thus sets up an error deflection on the governor that calls for the servomotor rotation to move the gate valve in such a direction to have the pressure approach the zero error position. As this approach is made, the speed of the servo becomes smaller and smaller, thus decreasing the rate of valve movement.

However, since there may be some time lag between a change of the gate valve controlling the air input and the fluid pressure actuating the Bourdon-tube pressure gage, the servo may have forced the gate valve too far so that the pressure will be above the desired control pressure. Thus the pressure tube gage finally rises high enough to cause reverse error, and hence reverse servo rotation. Again, owing to the time lag of the response of the Bourdon-tube gage, the pressure overshoots the proper control value in the opposite direction. (This condition is typical of the type of control response that will make the conventional torque-proportional-to-error system very unstable and limits allowable sensitivity greatly even with derivative control.)

Because of the fact that the servomotor velocity is proportional to the error on the hunting cycle (instead of having the torque proportional), the maximum servo velocity is small, so that the gate valve never moves far from its proper control position. This means that the maximum amplitude of the hunt oscillation can never grow too large. It can be reduced to any small desirable value by limiting the maximum velocity which the servomotor can attain. Thus the hunt period can be made as much longer than the time constant of the system as is desired, which has the property of decreasing the hunt amplitude just as much as desired. Of course, the system response may be too slow and sluggish if the motor speed is restricted too much. However, the static accuracy of the system does not suffer.

If the above servo speed-limiting results in too sluggish response for satisfactory hunt amplitude, several tricks can be played on the system. The first is to limit the speed of response in only one direction, leaving the servomotor speed in the opposite direction at its maximum. Observe the system operation in this direction. Then *interchange the speed limiting stops* so that the opposite direction has the slow speed. Select the most desirable mode of these two alternates and place a limit switch on the travel of the valve, so that as the servomotor travels in the high speed direction it soon runs into the limit switch. The limit switch thus coöperates with the governor to limit the high-speed excursions of the hunt amplitude to the smallest reasonable value allowable. The governor-adjust-stop limits the speed in the opposite direction so that only small hunt amplitude is allowed.

The above subterfuge becomes progressively less and less satisfactory as the time-constant of the controlled system becomes longer and the desired response is closer to perfect (*i.e.*, non-hunting dead-beat, "super accurate") This is not a reflection on the validity of Conditions 1 and 2, but only a malpractice brought about by nonconformity of actual relationships to the specifications of the theory for synthesizing the correct servomechanism.

The obvious solution is to make the governor speed conform to the velocity of the controlled variable rather than to the velocity of the servomotor. Likewise, the feedback should come directly from the controlled variable rather than from the servomotor position.

This may be relatively easy to accomplish in certain instances where large mechanisms are moved with sufficient force and power to permit gearing the governor directly to the mechanism through a suitably large gear ratio, such as is the case of a large mechanism controlled by air or hydraulic pressure and having the servomotor operate the control valve.

On the other hand, certain controls require that the error indication be taken from delicate indicating instruments such as gyroscopes, galvanometers, sensitive Bourdon tube movements, etc., and this will obviously require different technique.

Characteristics A and B suggest that extremely small force on the hand crank 1 (Fig. 1) would suffice to control the servomotor of Fig. 1, and that the accuracy of such control would be exceedingly high. Actual operating servos identical to Fig. 1 will display a sensitivity of 1 part in 20,000 to 1 part in 100,000 or 0.005% to 0.001%. Thus if the needle of the sensitive indicating instrument is substituted for hand crank 1, the position of the follow-up contact 2 bears a true relationship to the position of the controlled variable, and the speed of the rotor 3 of the follow-up motor is an accurate duplication of the rate of controlled-variable translation. Thus if the feedback for the inside feedback dial is derived from gear train 4 of Fig. 1, and rotor 3 drives the governor input speed, Conditions 1 and 2 are carried out in spite of the fact that there is a long time interval between the main servo ("61A") response and the appearance of response on the indicating needle. See Fig. 5.

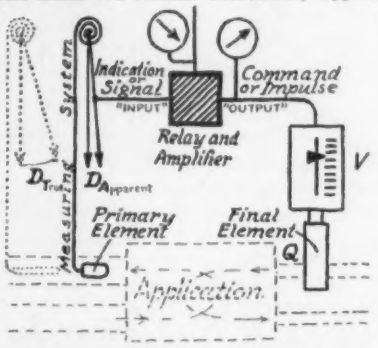
Because of the fulfilling of the Conditions 1 and 2, long-time-constant servomechanical control problems may be solved in the same manner as the short time constant problems, exactly according to the previously-explained theory. "Super-accurate," dead-beat, non-hunting operation consistent with maximum response speed and insensitivity to changes in load inertia, resistance and time constant is possible. A system thus synthesized is termed a "Genus III Motron servo for long time constant systems." Such a system is shown in the block diagram, Fig. 5. Such systems are not commercially available for civilian uses at the present time, but it is intended to make all essential components available to industry at a future date.

Conclusion

The information disclosed in the foregoing is believed to represent a radically new theory of servomechanical control. Since the theory is unorthodox and unencumbered with the usual trappings of the art, it is to be expected that those engineers and physicists most experienced in the art will be the most skeptical. Therefore, to engineers and physicists who are skeptical because of training and experience, and also to those who have no formal knowledge of this specialized field but are skeptical for different reasons, we ask to keep one simple thought-pattern in mind:

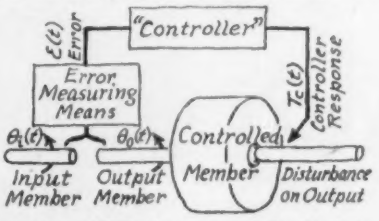
"To place a given object on a given spot and have it stay there, the object's velocity must be zero as it reaches the given spot." (Corollary of Sir Isaac Newton's First Law.)

NOTE ON TERMINOLOGY. — Control experts in different engineering fields use such different terminologies that each "language circle" seldom understands the others. As a rule, when accepting such an article for *Instruments*, we translate it into the universally-understood language of Instrumentation. We made an exception in this case because Mr. Robinette's theory is a *specific* one. In spite of this exception, a firm foundation of the language of Instrumentation remains the recognition of the *FACT* that an automatic controller consists of all elements from primary to final, as shown (for the pneumatic example) by the solid lines. We remain unalterably opposed



to the assumption that an automatic controller is only the shaded part. To repeat our 1924 argument: *Given an "application" (dashed lines) can you control it with the shaded part alone? You can't; you must specify and install the entire solid-line system. THIS, therefore, is the controller.*

We recognize that the simplifying assumption can lead to simple equations (such as those of Ziegler and Nichols); and also to useful extensions of electric feedback-circuit equations to the mechanical dynamics of gun-pointing servos, etc., as in this basic scheme used by Gordon Brown and his as-



sistants at MIT who successfully teach how to synthesize complete servo systems. But an automatic controller is more than a servo!—M. F. Behar.

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Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

III. THE FABRICATION OF MULTIPLE GLASS SEALS

Condensers, liquid traps, vacuum-jacketed distillation columns, diffusion pumps, liquid-level controllers, as well as numerous other parts of special glass equipment, require in their fabrication the use of the internal, triple or commonly-called ring seal. This seal is located where one tube passes through the end or side wall of another and actually forms a ring at the juncture of the tubes. The methods of making this seal may be divided into two classes:

1. The inner tube is not supported when the seal is made.
2. A support of the inner tube is necessary because of its weight or position.

Ring Seals With Inner Tubes Unsupported

The simplest ring seal is the type in which a short length of tubing is sealed into a larger tube. The beginner must master this seal on a small scale to be successful in more complicated work where more than one or larger ring seals are required. The steps in making a ring seal with an unsupported inner tube are illustrated in Fig. 41.

1. A tube with a diameter of approximately 16 mm. is drawn to a point. This point is then held in the left hand and the opposite open end is closed by fusing the glass, attaching a glass rod and pulling the tube end to a cone. In this step one must not forget that the glass tube should be rotated in the burner flame for even wall thickness in the cone. The tube is opened at the apex of the cone by heating this point until the lens-shaped form of fused glass has the diameter of the smaller tube which is to be sealed into the prepared opening. This glass is blown out to a small bulb, reheated and finally blown out to a thin-walled glass sphere. If one is careful in scraping away the glass, a small flare is retained as a foundation for the ring seal, Fig. 41A. The opening should be about 11 mm. in diameter.

2. A small tube, 10 mm. in diameter, is heated at the desired location for the ring seal. A short section, ½" in length, is fused and a small bulb is blown. Immediately after the bulb is blown and while the glass is still in a plastic state, the two ends are pushed together to form a tube section as shown in Fig. 41B. The outside diameter of this glass shoulder should be only slightly larger than the diameter of the opening on the larger tube.

3. The open point end on the large tube is sealed and the smaller tube is placed in position so that its shoulder rests on the small flare at the opening of the large tube, Fig. 41C.

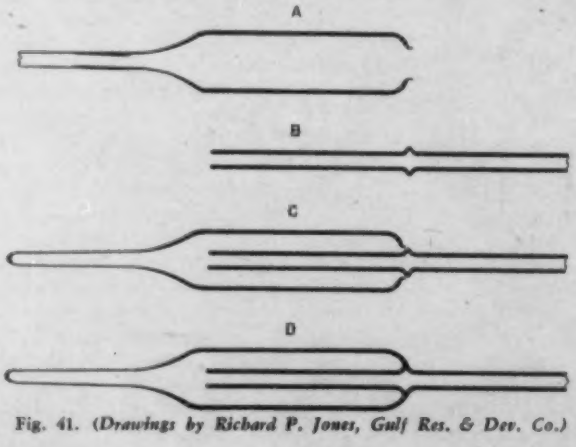


Fig. 41. *(Drawings by Richard P. Jones, Gulf Res. & Dev. Co.)*

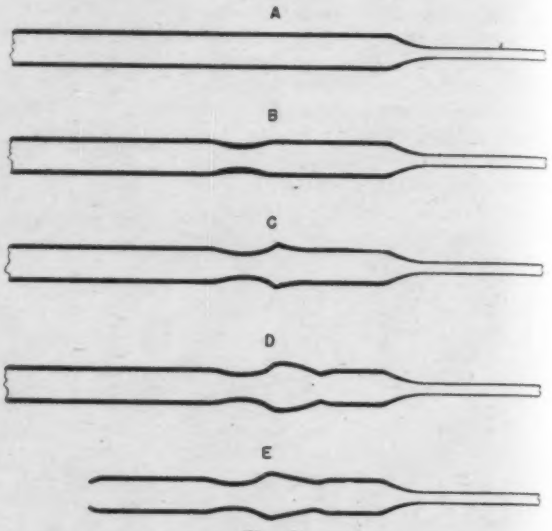


Fig. 42

4. The ring seal is made by holding the two tubes together while rotating them in the flame. The glass should be fused sufficiently at the juncture of the two tubes to yield a good leakproof seal. Subsequent collapsing and expanding at the seal is required to work the glass. During this work one must be careful to balance the inner tube by adequate rotation. After the seal has been completed it is heated sufficiently for final alignment of the center tube. It is then annealed. The completed seal is shown in Fig. 41D.

It is frequently desirable to butt seal a side arm on the shoulder or rounded portion of the large tube. When a side arm is required, as in the case of condensers, the ring seal must be kept hot to prevent it from cracking while the side arm is being attached. The latter, if placed near the ring seal, will be most efficient functionally if the fabricated glass is to serve as the end of a condenser. Side arms close to the ring seals are also required for traps.

The fabrication of a suitable side arm will depend upon the shape and form desired for connecting auxiliary equipment. It is also important to make the side arm before the ring seal is started so that no time is lost in butt sealing the former to the outside tube. Under such conditions the finished ring seal need not be reheated. The successive steps in making a side arm for a rubber tube connection are given in the following steps.

1. A point is drawn on the glass tubing as shown in Fig. 42A.
2. The tube is then constricted by fusing the glass at a point one inch from the shoulder of the point. The tube must be rotated in the burner flame and one must be careful not to pull or push the ends of the glass while the constriction is being formed, Fig. 42B.
3. The glass is then heated at the right of the constriction until the glass begins to soften sufficiently so the tube can be pushed together to form a small bulge, Fig. 42C.
4. The glass to the right of the bulge is constricted by fusion, Fig. 42D.
5. The tube is then cut to the desired length by technique of preparing a tube end for sealing, Fig. 42E.
6. The side arm is sealed to the glass tube containing the ring seal by the procedure outlined under butt sealing.

One should be careful to keep the ring seal hot while the side arm is attached. The position is shown in Fig. 42A or B.

The fabrication of uniform and reproducible drop counters is quite important in the production of ebulliometers. The ring seal is made by using a special inner tube which is fabricated as illustrated in Fig. 43D and E.

1. The counter is formed by fusing the end of a glass rod until the fused ball has the required diameter, Fig. 43D.

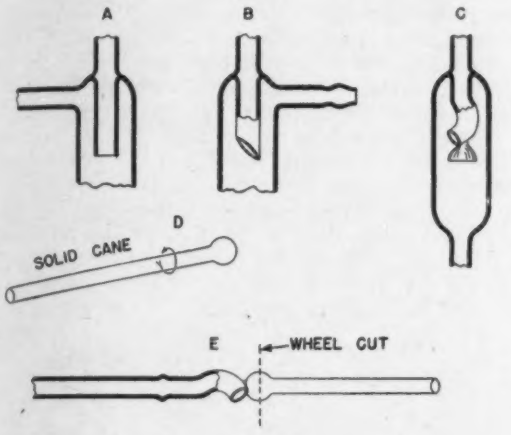


Fig. 43

The diameter is increased by fusing the glass of the rod and allowing the glass to flow to the glass sphere. The rod must be rotated during the fusing process.

2. The inner tube is prepared by heating a short section and expanding the fused glass with air pressure. The tube ends are pushed together during this operation to form a small shoulder of glass.

3. The end of the dropper is completed by bending the tube to one side of the shoulder, Fig. 43E. The tube is cut at the bend with the flame and the ball is attached by fusing both the one edge of the tube end and the ball and pushing the two together. The ball is then cut on the cutting wheel at the center indicated by the dotted line, Fig. 43E.

Ring Seals With Inner Tube Supported

The inner tube of a ring seal must be supported when it is long and heavy or when the tube is to be sealed in a definite position as through the side wall of the larger tube. Ring seals are best made by applying air pressure to both sides of the inner tube. The fabrication of glass holders for supporting one tube has been described as simply butt sealing a small tube to a larger tube and cutting the latter with an abrasive wheel. When inner tube supports are required, a holder is fabricated as illustrated in Fig. 44A.

1. One end of the holder is made by butt sealing a small tube to a large tube. Instead of cutting the latter on the end opposite the seal, a second tube is butt sealed to the large center tube. This small tube is cut with an abrasive wheel to the desired length, Fig. 44A.

2. It has been pointed out that in the fabrication of ring seals, means of applying air pressure to both sides of the inner tube are necessary. If the larger end of the holder is to be used for applying air pressure, openings on the shoulder near the seal of the smaller tube will make it possible to obtain pressure in the tubing assembly. These openings are made by heating a spot on the large tube shoulder until the glass is fused and then drawing out the fused glass with a glass rod, Fig. 44B.

3. The thin cone-shaped glass is scraped away and the opening is fire polished, Fig. 44C. Three or four openings are sufficient.

After the openings are made, the holder should be rotated in the left hand to test the smaller tube for exact alignment. Several holders with different tube sizes and lengths should be prepared for future use in the fabrication of ring seals.

A definite procedure should be adopted when glass equipment is being made. The beginner will find that considerable time is saved if the various parts of the proposed equipment are first prepared. This is especially important when ring seals are involved because once the equipment is being assembled the work need not be interrupted until all seals are made. The reheating of a ring seal which has been allowed to cool is time consuming.

The production of a ring seal by supporting the inner tube is best performed by first making the integral parts required for the total assembly.

1. The inner tube is flared by rotating the end of a tube in the burner flame and opening it with a triangular flaring tool. One must be careful to prepare the flare with uniform wall thickness, Fig. 44D.

2. The outer tube is made by supporting one end of an open tube length with a holder. Asbestos tape is used for holding the tube on the holder. The opposite end is closed to a round end, Fig. 44E.

3. The side arm and the tube extension of the inner tube are prepared as previously described. Both should have axial points.

4. The inner tube is supported on the small tube end of the holder by using asbestos tape. The outer tube is then supported on the enlarged section of the tube holder with asbestos tape, Fig. 44F.

5. The tip of the round end of the larger tube is fused by rotating it in the burner flame until the glass of this large tube is fused to the inner tube.

One should be careful not to collapse the glass of the outer tube behind the point of contact between the tubes. The fused glass is blown out slightly and fused again to insure a good seal between the inner and outer tubes. The glass covering the flared end of the inner tube is then fused and blown out to a small bulb. This bulb is heated with rotation until the glass is fused to within an eighth of an inch from the ring seal and blown out to a thin walled bulb. The glass is scraped away with a forceps and the end is fire polished. The inner tube extension which was prepared before the ring seal was started is immediately butt sealed to the opened ring seal. The open point end of the inner tube extension is used for applying air pressure while the open end of the dual tube holder is closed with a small cork.

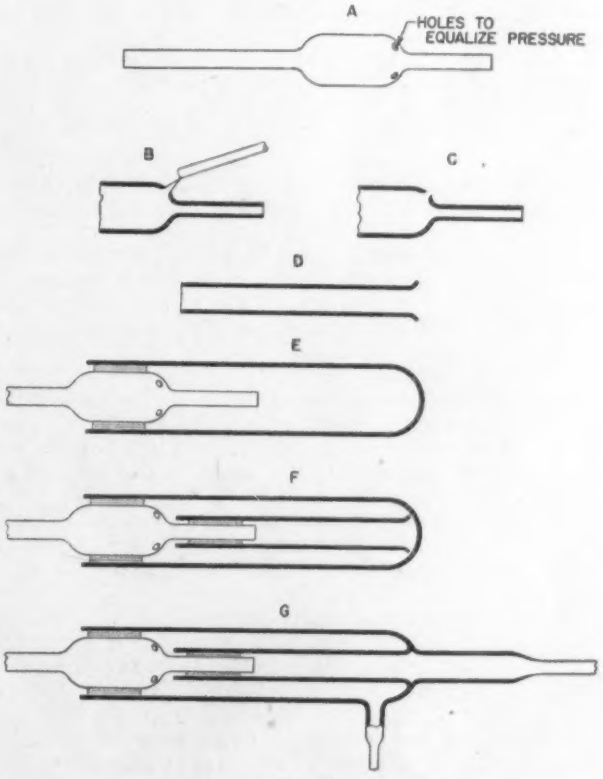


Fig. 44

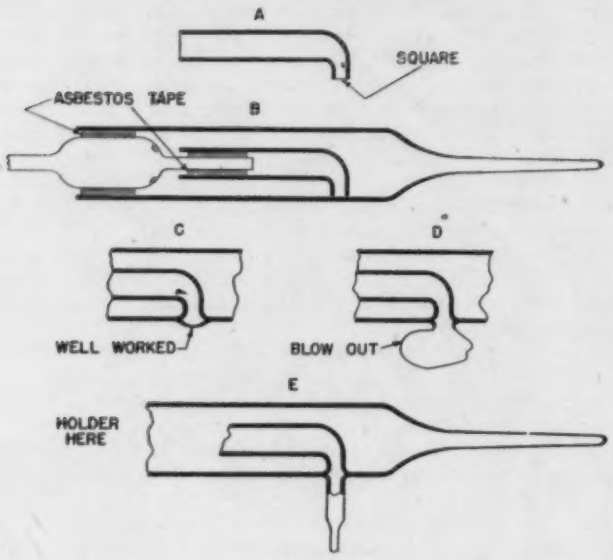


Fig. 45

After the butt seal of the inner tube is completed the side arm is immediately sealed to the outer tube, Fig. 44G. The entire assembly is then annealed and allowed to cool. The holder is then carefully removed.

A ring seal at the wall of the outer tube is frequently required and is made by using the dual glass holder. All parts of the complete assembly should be made before the ring seal is started.

1. The inner tube is made by bending a glass tube at a right angle. The tube is cut squarely with the flame and fire polished. It is important that the end be square, Fig. 45A.

2. The extension for the inner tube is prepared in the usual manner by first pulling a point on the tube and then opening the other end with the burner flame.

3. The outer tube is mounted on the glass holder with asbestos tape and a point is drawn on the tube. The holder is then removed and the inner tube is mounted on the holder tube. The inner tube should be centered and should also touch the outer tube wall. The outer tube is mounted as shown in Fig. 45B.

4. The outer tube is rotated in the burner flame until it is hot but not to the extent that it is pliable. It should be heated periodically in this manner as the seal is made. The outer tube is then heated at the point where the inner tube touches the outer tube wall until the glass is fused sufficiently to form a seal with the inner tube. The glass at this point is worked by blowing it out, Fig. 45C, and collapsing it by fusion.

5. After a good seal is obtained at the juncture of the inner and outer tubes, the glass is fused and blown out to a small bulb which in turn is fused and blown out to a thin-walled sphere, Fig. 45C. The excess glass is scraped away and the opening is fire-polished.

6. The tube extension is sealed to the ring seal. The point of this tube is used for applying air pressure while the glass holder end is closed with a small cork. The procedure used in making this seal is simply a side arm sealing technique. The completed seal is annealed and allowed to cool. Extreme care must be taken in removing the glass holder because of the torque which can be developed if the end of the holder is moved away from the true center. It is best to remove the holder by pulling it out with slow rotation.

Whatever types of ring seals are required, or whatever method is used in making them, ring seals at the opposite ends of two annularly spaced tubes present the problem of completing the seals without setting up too many stresses at the fabricated ends. After both seals are completed the outer tube must not be heated rapidly or expansion will cause the inner tube to break because of strains.

The fabrication of a glass condenser will be considered next in the study of ring seals. All parts such as inner tube extensions and side arms are made before the work on the condenser is started.

1. The one end of the outer tube is prepared as described and shown in Fig. 41A. A glass holder is used to hold the tube instead of drawing a point, because the inner tube is inserted through the open end. The end which is opened by the burner flame should, in this case, have an opening slightly smaller in diameter than that of the shoulder of the inner tube. This tube is also flared at the end where the second ring seal is to be made. The flare is slightly smaller in diameter than the outer tube opening so that the inner tube can be inserted in the larger tube. If this tube is long or heavy, it should be supported by inserting a dual glass holder into the large tube end as well as the inner tube. The glass at the juncture is heated and the seal completed as described before and shown in Fig. 41A.

2. A second method of making the first ring seal would be to follow the procedure outlined in Fig. 44. The inner tube is flared on both ends and inserted into the outer tube which has a rounded end. The seal is made as previously described and as shown in Fig. 44E, F and G. The side arm serves as an opening for applying air pressure to the outside of the inner tube when the second ring seal is made. The ring seal is then annealed.

3. The glass extension of the inner tube which was sealed at the ring seal is taken in the right hand after the end is cool, Fig. 46A. The holder is removed and the open end of the large tube is drawn to a point so that the shoulder formed almost touches the flare, Fig. 46B. This shoulder is heated until the glass collapses and forms a seal at the flare edge. A good seal is made by pulling away the excess glass, Fig. 46C, and working the glass at the seal by repeated collapsing and expanding. The application of air pressure to the side arm will keep the outside tube from collapsing behind the ring seal. The end is then heated and blown out to a thin-walled glass sphere which is scraped away. The end is fire-polished and the tube extension is butt sealed to the condenser. The side arm is attached close to the ring seal. The glass is then annealed.

Special Condensers and Jacketed Burettes

There are occasions when special inner tubes or section of several bulbs are required for condensers or constant-temperature gas burettes. No elaborate inner tube holder need

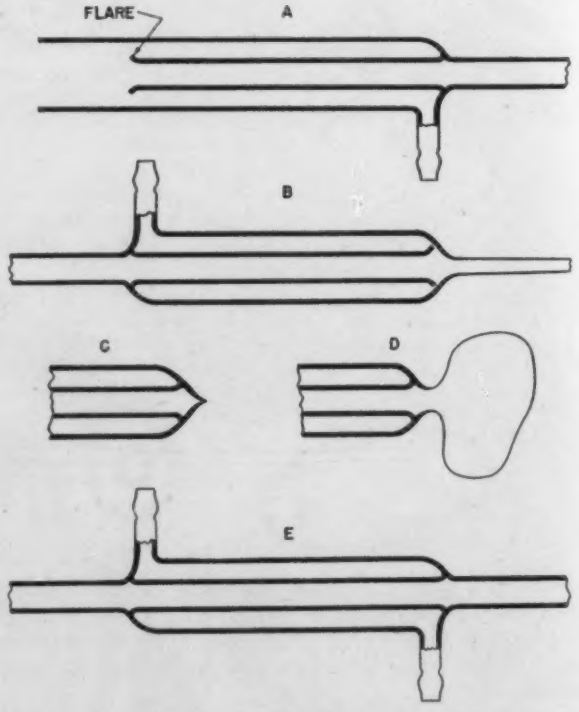


Fig. 46

be used because of the size of the inner tube assembly. Several strips of tape are sufficient for holding the tube.

1. The outer tube which is to serve as a jacket is rounded at one end as shown in Fig. 47A. The technique in making round bottoms on large tubings has been described and shown in Fig. 35.

2. The bulb assembly, Fig. 47B, is fabricated by making three bulbs by the procedure described before and shown in Fig. 38. Capillary tubing (2 mm.) is sealed to both openings of the first bulb while only one capillary is sealed to each of the remaining bulbs. One capillary tube is used as a handle which is held in the left hand. The second capillary tube is opened by the flame at the desired point. The second bulb which has but one capillary tube sealed to one opening, with the second opening as prepared in Fig. 31, is sealed to the capillary of the first bulb. The capillary of the second bulb is cut with the burner flame and the third bulb is sealed to the assembly.

3. The fabricated bulb assembly now has a capillary tube at each end. One tube is opened near the large bulb with the burner flame by first making a small thick-walled bulb. This small bulb is cut at its largest diameter by heating and fusing the bulb at the tip until the glass is fused to the diameter of the bulb. This fused glass is blown out and removed by scraping away the thin-walled sphere. The end is fire-polished and flared with a round carbon tool. The glass is allowed to cool and the second end is prepared in a similar manner.

4. The inner tube assembly is then put into the outer tube. Several strips of asbestos tape, between the bulb nearest the open end of the outer tube, and the outer tube, will be sufficient to hold the assembly for the fabrication of the ring seal.

5. The inner tube extensions and the two side arms are prepared before the work is continued.

6. The first ring seal is made and the side arm is sealed to the outer tube. It is desirable to bend the first side arm as shown in Fig. 47D to prevent kinking of rubber tubing if the jacketed condenser or burette is used in a vertical position. The second ring seal is completed and the side arm is sealed as shown in Fig. 47E. The ring and side arm seals are annealed as soon as they are completed.

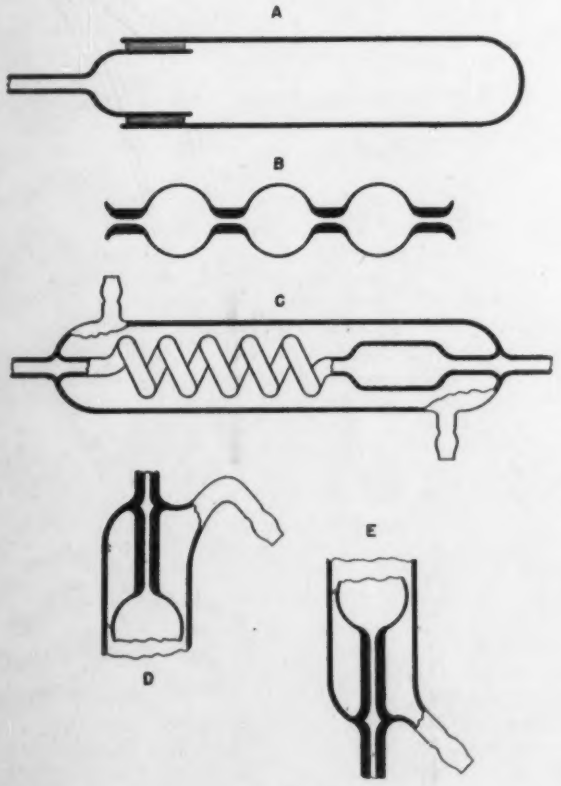


Fig. 47

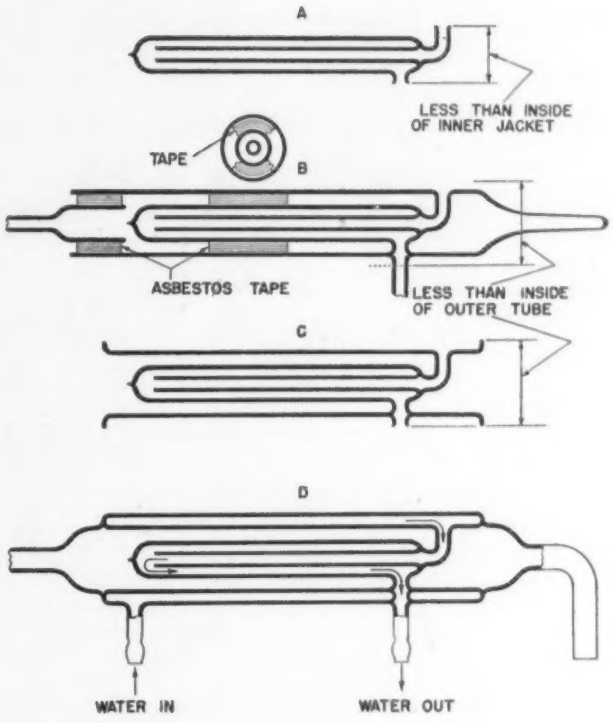


Fig. 48

A condenser with a combination spiral and straight inner tube is shown in Fig. 47C. Fabrication of spirals will be described later. The condenser is made exactly as has been described under the procedure outlined for making the glass-jacketed gas burette.

It is not necessary to describe the various designs of condensers or traps which could be made. There are many types of commercial condensers and traps which can be obtained for specific laboratory work. One condenser which is useful will be described because several types of ring seals are required in its fabrication. This condenser consists of a combination of a straight water jacket and pencil condenser, Fig. 48D.

1. Four different tube sizes are chosen to properly proportion the annular spaces and to allow a maximum distance for the side wall ring seals. The lengths of the respective tubes will depend on the desired length of the condenser.

2. The pencil condenser is made by the procedure outlined for making a simple trap. The inner tube is supported only if it is long and heavy. A small point at the end of the condenser will aid in causing reflux to drip from the end of the pencil condenser. The extension or center tube is bent at a right angle. Both this tube and the side arm tube are cut in the burner flame and flared so that the entire diameter is a little smaller than the inner jacket tube. Fig. 48A.

3. An axial point is drawn on the inner jacket tube and the pencil condenser is put into the inner tube and held in place with tape, Fig. 48B.

4. A glass holder is taped to the end of the inner tube of the proposed outside condenser and the point end is closed by sealing the glass. Three side arm tubes are then made, two of which are fabricated for hose connections. The ring seal is made first by heating the outer tube by rotating it in the burner flame and then fusing the glass of the outside tube until a seal is made with the side arm of the pencil condenser. The glass is blown out slightly by applying air pressure to the open end of the glass holder. One must be careful that the glass covering the opening is fused sufficiently to be blown out to a small bulb without deforming the glass around the outside of the point of contact. The glass covering the side arm

Continued on page 90

INSTRUMENTS ON THE MARCH

Navigational Instrument is First Peace-time Application of Radar

[SEE FRONT COVER]

SCHENECTADY, N. Y.—Growing out of General Electric's research and production of radar equipment during the war, the electronic navigator—a shipboard radar equipment for commercial vessels—was the first peace-time application of radar. The equipment can detect through darkness, fog, or storm the position of any above-water obstacles such as lighthouses, buoys, icebergs, other ships, and land, up to a distance of 30 miles depending on the size of the object. It will revolutionize "thick weather" navigation, providing the mariner with an instrument to plot a safe course even though his normal visibility is strongly limited by natural conditions.

Installed in the chartroom or wheelhouse [as shown in cover photo] the electronic navigator gives a radar map of the area surrounding the ship. The map may be 4, 12, or 60 miles in diameter, with the position of the ship itself always at the center. Objects only 200 yards away are shown when the 4-mile map is used. All types of commercial and private boats — yachts, ocean liners, freighters—will find use for such equipment.

Precision Oscillator for Radar, RCM and Walky-talkies

JAMAICA, N. Y.—Details of a test oscillator which aided in insuring satisfactory operation of U. S. Army and Navy radar equipment, as well as jamming enemy radar systems, have been disclosed by its manufacturer, Fairchild Camera & Instrument Corp. Another principal use of the instrument is in connection with radio communications. During battle thousands of radio messages crowd the air and the only way our men can be sure of communicating with their own headquarters is to send messages on predetermined wave-lengths, and then identify their answers by getting them on exactly the same (or another definite) wave-length. By means of the portable precision test oscillator, radio sets are quickly and infallibly checked and adjusted.

An original design of NDRC's radio research laboratory and the General Radio Company, but re-designed for quantity production by Fairchild Camera & Instrument Corp., the test oscillator is said to represent a miracle in mass manufacture of individually-calibrated units

The instrument is particularly valuable in checking radar counter-measure (RCM) equipment. Unless RCM is regularly checked by the test oscillator, its radio response is untrustworthy and meaningless. Frequently search receivers pick up signals from our own airplanes and ships instead of the enemies'. The only way to trust their response is to have pre-tuned receivers whose frequencies have been constantly checked, and to send back our counter-signals on accurate wave-lengths. Then, even in darkness, we can be sure that our own men are not being shot down, because the wave-lengths of enemy radar signals are jammed. The test oscillator can furnish radar pulses measured in microseconds of the required critical accuracy.

Primarily designed to provide a source of calibrated high-frequency signals for testing in the field, the instrument delivers a small fraction of a watt, which is sufficient for test, but not strong enough to interfere with other radio equipment in the vicinity. Using a conventional triode, it covers the frequency range in two bands, 40-115 Mc. and 115-500 Mc. An adjustable pick-up loop provides control of the output power. Either an unmodulated or a modulated signal can be obtained. The modulation may be either 1000-cycle sine wave (simple musical tone) at about 50% modulation, or a special short regulated pulse used in certain classes of equipment.

The complete test oscillator is composed of four main subassemblies: (1) an aluminum casting forming the main chassis upon which the other subassemblies are mounted; (2) the butterfly circuit assembly, mounted on an individual casting; (3) the power supply and modulator shelf, a compact unit mounted on the main casting and containing transformers, tubes and other components; and (4) the panel with controls, power cable receptacle and output connector installed on it.

All these major components are independently removable and replaceable; are especially adaptable for mass production manufacture and easy servicing in the field.

The oscillator frequency is controlled by the butterfly circuit, one path of which may be opened by a switch. For the high-frequency band, the switch remains closed and the butterfly operates normally. For the low-frequency range, the switch is opened. An external permanently-connected coil completes the butterfly circuit and resonates with the butterfly capacitance.

Output power is obtained through a pick-up loop, rotated in the magnetic field of the oscillator-tuned circuit. This power is fed through a 50-ohm coaxial line to an output connector mounted on the panel. The output connector can be used for two different purposes: as a receptacle for a connector in direct connection to a receiver, or as a mount for a built-in antenna that can be pulled out for direct radiation.

The test oscillator operates either from an a-c. or d-c. source. A switch permits adaptation of the instrument for use with a-c. frequencies from 50 to 2600 cycles at voltages of 80, 115, or 230, such as may be found in commercial power systems of this or foreign countries, as well as in certain aircraft power systems. It is also made adaptable for use with d-c. voltages of 6.3 and 220. For operation with battery supplies, the 220 volts are obtained from five 45-volt dry batteries, and the 6.3 volts from four 1.5 dry batteries, or a storage battery. When operating on d.c., the rectifier tube not being needed is automatically switched out of the circuit.

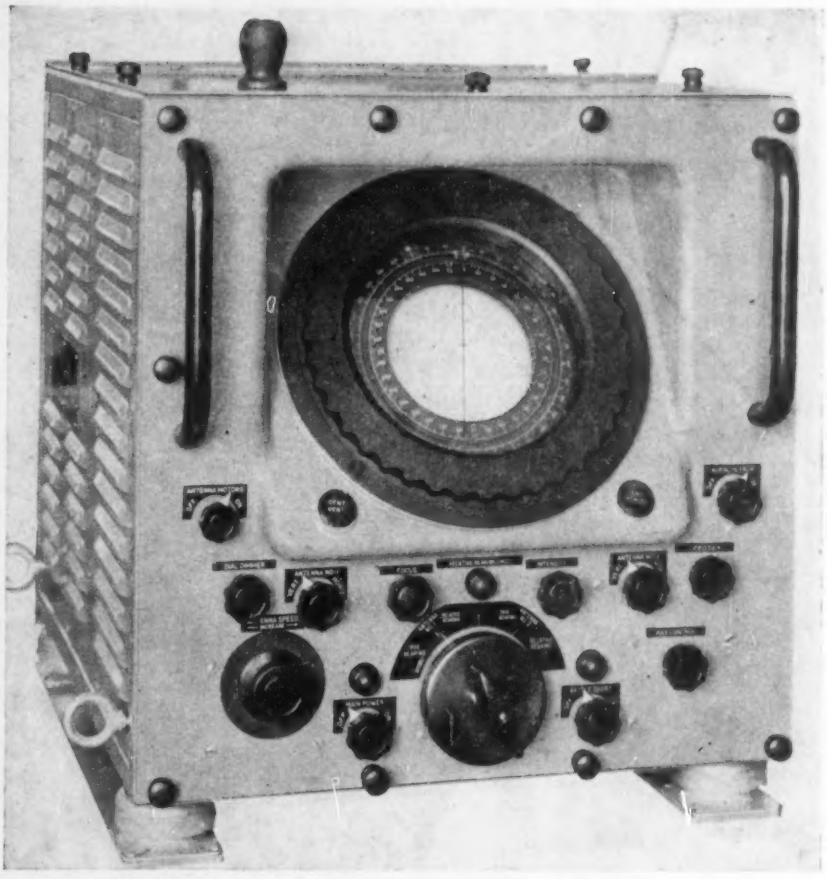
Noteworthy component of the instrument is its oscillator-tuned circuit, a modified insulated rotor butterfly with two sets of 120° split stator plates and 240° rotor plates (a floating rotor). A three-turn coil is permanently connected across a gap in the stator or inductive element of the butterfly, and a range switch is used to open or close this inductive element. The range switch itself is composed of a number of spring vanes that slide in slots in the butterfly stack. This provides multiple contact with consequent low inductance and resistance.

Noteworthy feature of the butterfly tuner is that it varies both the capacitance and inductance in an arrangement as simple as a variable capacitor, but without any electrical connection to the rotor assembly necessary. This eliminates troubles that usually develop when contacts are made to rotating parts.

Good design and extreme precaution in production have virtually eliminated the most troublesome operating characteristic of all such oscillators, *i.e.*, the drift caused by the radio set warming up. Warm-up time is not required for measurements of moderate precision, but only for those of extreme precision. The method by which this is accomplished is still not to be revealed.

Another advantage of the butterfly tuner is that it is small and compact, and takes the place of larger tuned circuits which would be needed at the frequencies used. Even so, the positioning of its stator and rotor plates is very critical, and these are held to an overall tolerance of 0.0003" with individual plates ground to 0.0001". Despite its small size, it can operate over the exceptionally wide frequency range of 40 Mc. to 500 Mc., with harmonics usable at much higher frequencies.

This precision instrument is being produced exclusively for the U. S. Army and Navy in quantity lots. For postwar use, it should make a useful instrument for amateurs with little money to spend, as well as for large radio and television laboratories.



Instrument for Locating Enemy Radar

BOSTON.—American Naval vessels easily located and identified Nazi and Jap radar installations through the use of an automatic radar direction finder, it can be revealed now that secrecy on Radar Counter-measures has been lifted. This ingenious electronic instrument, manufactured exclusively by the Submarine Signal Company, revolutionized the entire search technique for enemy radar sets. By means of its visual display of the direction-finding information on a cathode-ray tube, the operator could actually see the presence of the enemy installations.

Developed in the closest connection with the NDRC Division 15 Radio Research Laboratory set up at Harvard University and devoted to RCM, the Submarine Signal radar direction finder was one of the most versatile war instruments. It measured the frequency of the intercepted signal as well as the direction from which it came, and was the only direction finder that could receive successfully the ultra-high frequency signals produced by the very latest radars.

The radar direction finder was so sensitive that the experienced operator could look at the picture on the scope produced by the intercepted signals, tell what kind of radar had produced the signals — anti-aircraft, surface search, gunfire control, etc.—and deduce the size and class of the ship carrying the intercepted radar.

In the course of its first trial run aboard a destroyer escort, the equipment clearly demonstrated its remarkable capabilities. During maneuvers offshore at night the radar operator of the DE made contact with a target at a certain range and bearing. The countermeasures operator, meanwhile, picked up a number of different radar signals all having the same bearing. From the characteristics of these signals, as well as from the frequencies at which they were tuned in, he deduced that the vessel detected must have been a U. S. cruiser. When this information was reported to the bridge, the captain's amazement at the powers of electronics could not have been more profound.

Dusty Air No Longer Clogs Combustion Controller

PITTSBURGH, Penna. — Development by a southern engineer of a new feature for combustion control systems, to meet conditions where fine dust in the air stops up the automatic-regulator mechanism, has been reported by the Hagan Corporation, combusiton engineers.

The improvement was in the plant of the Southern Box & Lumber Company, Wilmington, N. C., where G. Colucci, president, reported the difficulty. At the suggestion of J. T. Potter, Hagan and Hall Laboratories representative in that state, the engineer not only enclosed the automatic regulator in a box to keep out the fine dust but went one step further: he ran in a compressed-air line and kept a little positive air pressure in the box. This procedure made more certain that the regulator would stay clean.

Incidentally, this solution could be of value in many other industries.

Inspectors Use Plant Intercom to Check Flaws

AKRON, Ohio—The microphone has joined the micrometer and other tools that make up the equipment of the modern industrial inspector.

To speed up war production, inspectors in certain departments of the B. F. Goodrich plant literally talk across the products they are inspecting into a special public address system, their "verdicts" going straight to the man doing the work.

Seated before a microphone, the inspector need only reach up and pull a callboard lever to "get the ear" of the responsible worker by way of a speaker horn suspended above the latter's place of work. Thus a deficiency occurring in one "heat" or molding operation, for example, can be spotted before the error is repeated. The workman can press a button and "talk back" through the speaker, which will pick up speech as far as 50 feet away.

The "mike" and speakers are credited not only with saving money and valuable wartime rubber, but also with

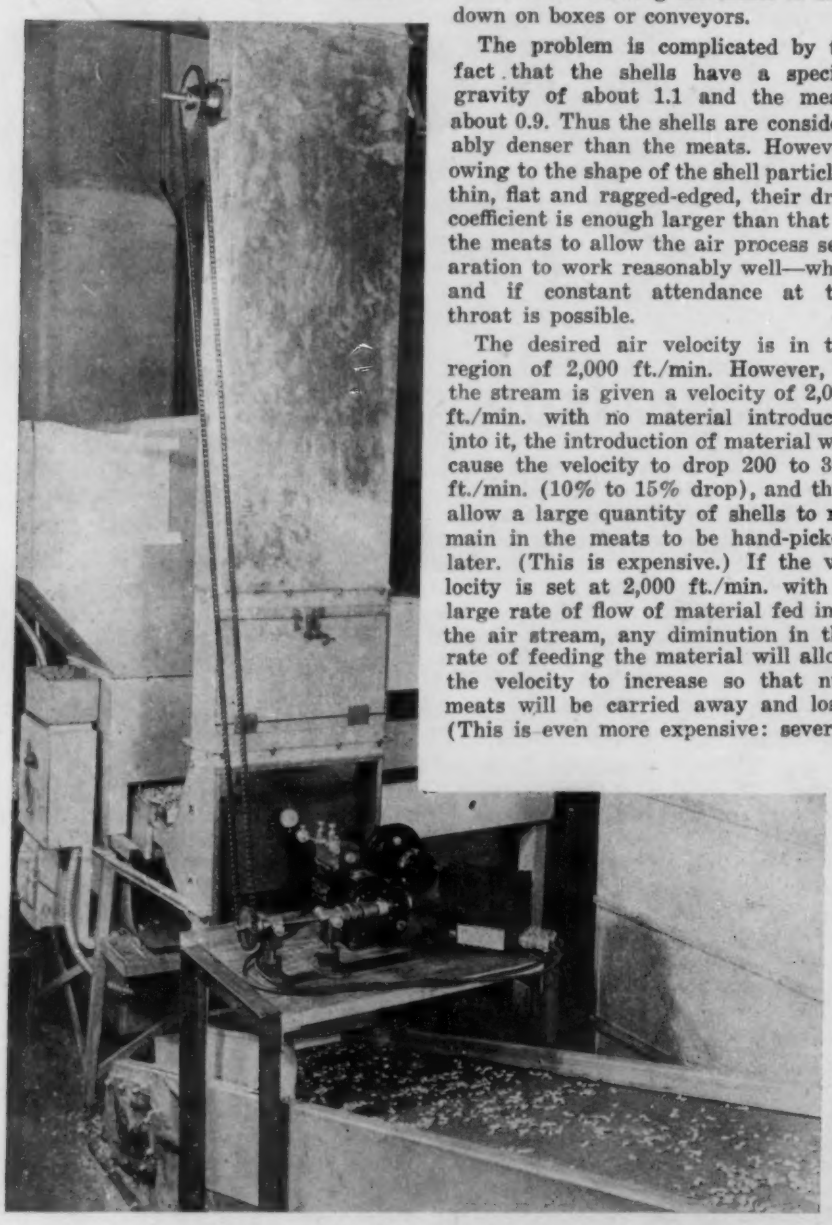
speeding up production of carburetor diaphragms used in warplanes, as well as of brake cups, hydraulic brake rings and sealing rings, fuel cell parts and other items.

In Mill 4, home of the Miller Rubber division of B. F. Goodrich, the loudspeaker system has been in operation for a year and a half. A 21-station system reaches departments on five different floors and, when not being used for inspection reports, carries recorded music and news broadcasts to the workers. It has been so effective that a similar system with 20 stations has recently been installed in the industrial products division.

The idea of using loud speakers for this purpose originated with Frank E. Trockle, general superintendent of Mill 4. He borrowed a microphone and speaker and connected them up between the inspector and one diaphragm mold. The experiment was so successful that he called in Solomon Liebowitz, of the Electronic Engineering Company in this city, who designed the two systems now in use.

Instrumentation Solves a Nut Industry Problem

SOUTH PASADENA, Calif.—The California Walnut Growers' Association have the problem of separating cracked walnut shells from a mixture of walnut meats and shells. This has been accomplished in the past by feeding the material into an air separation throat which is connected to a cyclone and suction-side of a centrifugal fan. The fan pulls a high-velocity air stream through the throat and floats out the shells while allowing the meats to drop down on boxes or conveyors.



The problem is complicated by the fact that the shells have a specific gravity of about 1.1 and the meats about 0.9. Thus the shells are considerably denser than the meats. However, owing to the shape of the shell particles, thin, flat and ragged-edged, their drag coefficient is enough larger than that of the meats to allow the air process separation to work reasonably well—when and if constant attendance at the throat is possible.

The desired air velocity is in the region of 2,000 ft./min. However, if the stream is given a velocity of 2,000 ft./min. with no material introduced into it, the introduction of material will cause the velocity to drop 200 to 300 ft./min. (10% to 15% drop), and thus allow a large quantity of shells to remain in the meats to be hand-picked later. (This is expensive.) If the velocity is set at 2,000 ft./min. with a large rate of flow of material fed into the air stream, any diminution in the rate of feeding the material will allow the velocity to increase so that nut meats will be carried away and lost. (This is even more expensive: several hundred dollars' worth of meats per hour may be lost.)

It has been determined that 25 to 50 ft./min. air speed variation (1.25% to 2.5%) is about the maximum allowable if consistently effective material separation is to be maintained. This represents a difference in dynamic pressures of approximately 0.01″ of water.

With the uncontrolled throat, line voltage variations, as well as changes in suction area by shells tumbling in the suction pipe and cyclone, prevent attaining this close velocity even if each throat has a separate adjustable-speed fan. It is not possible to use a central large-capacity suction manifold, but each throat must have its own cyclone and fan, which adds to the capital investment.

The photograph shows a preliminary test installation of a "Motron" Servomechanism for the control of air velocity in the separation throat. A drag sphere (a ping-pong ball) is fastened to the governor counterweight arm and extends into the air stream through a slit in the glass front of the throat. An adjustable counterweight slides back and forth on the arm to regulate the effective weight which the air drag on the sphere must lift in order to actuate the governor, or to adjust the regulated air velocity. The servomotor drives the damper through the chain drive.

The installation required approximately one-half day of experimentation after the construction of the platform and damper. Several styles and types of drag mechanisms were tried before the pictured drag sphere was found to be satisfactory.

The only adjustments are the two speed-limiting stops on the top of the governor case. These stops are restricted so that the hunting oscillations are small enough to keep the drag sphere barely moving. This results in a maximum damper speed of approximately five degrees per second.

The unskilled help took over the operation and adjustment of the "Motron" servo after approximately one-half hour of instruction.

Over a period of a week, in which the machine was cleaning "pills," *i.e.*, small fragments of nut meats and occasional shells, a box of the cleanings showed no nut pieces larger than 3/32″ in diameter. (Material of this size is ordinarily extracted and pressed for the nut oil.) In general, the performance seems to be excellent. The servo is sensitive, but its action is stable.

"War of Instruments"

NEWARK, N. J.—The total number of electrical measuring instruments produced at the Newark Meter Works of the Westinghouse Electric Corporation for use by the U. S. armed forces in World War II was 3,239,547 — enough to have provided each soldier of General George Washington's Continental army with 13 if he could or would have carried them.

Oscillograph Depicts Electric-eel Discharge

PASSAIC, N. J.—Before hundreds of members of the New York Zoological Society gathered at the Waldorf-Astoria in New York City for their Fiftieth Annual Meeting, two electric eels wrote their shocking story in electronic terms on a large screen for all to see. By means of the latest Du Mont oscillograph provided with a special projection lens, the "radar" or exploratory impulses as well as the real lethal shocks were shown in wave forms. The demonstration was under the deriction of Dr. C. W. Coates.

A glass-sided water-filled tank about six feet long, with conducting screens developed by the Allen B. Du Mont Laboratories, Inc., of Passaic, N. J. This oscillograph obtains the high luminosity necessary for projection by utilizing a new high-voltage cathode-ray tube operated at a total accelerating voltage of 20,000 volts. The 5" diameter cathode-ray tube image is projected onto a screen developed for this purpose, by means of a special 6" focus lens rated at f:1.5, an exceptionally large aperture. For this demonstration, the image was projected on a 3' × 4' screen in a shadow box because of the brilliant lighting of the auditorium.

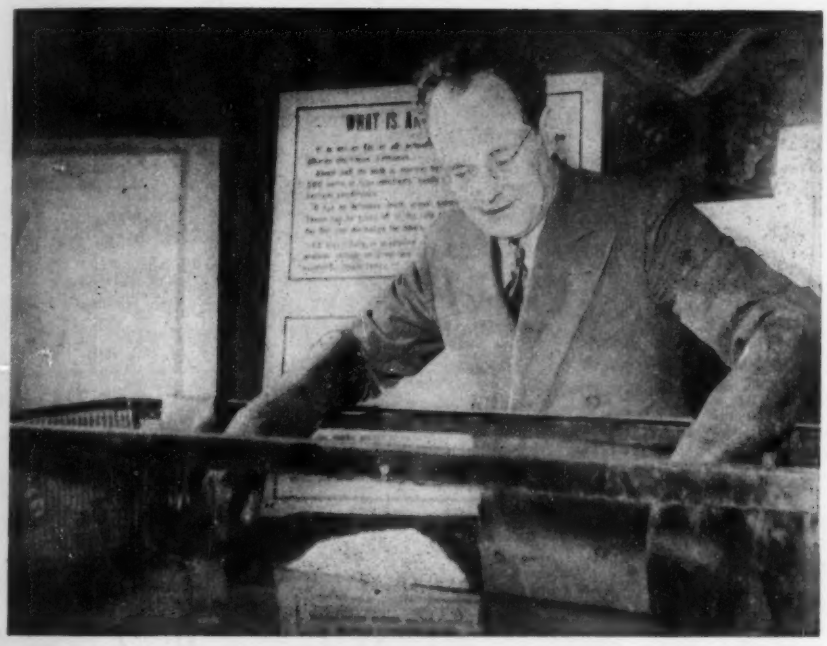


Fig. 1. Dr. A. W. Coates wearing rubber gloves as a safeguard against electric-eel shock. The electric eels are contained in this tank which has screen electrodes at both ends to pick up the electric discharges which are graphically shown on a large screen by means of a projection-type cathode-ray oscillograph.

of electrodes at both ends (see Fig 1), contained the two live specimens of *electrophorus electricus (Linnaeus)*. To naturalists, they are really not eels but eel-shaped fish, measuring four feet or more in length and six inches and up in girth. About half the flabby bulk is electric-generating tissue. The electric eel can generate about 500 volts and is fully capable of killing a man under certain conditions. Otherwise the electric eel has no defense—no teeth, no armor. It depends entirely on its shocking power. It can give off discharges at the rate of several hundred per second and sustained over a period of hours without "running down."

The electricity is produced by neurophysiological action. In the process certain enzymes are manufactured, which are of immense scientific importance.

In order to depict to his audience the nature of the discharges, Dr. Coates made good use of a new experimental projection-type oscillograph recently

Dr. Coates demonstrated the two kinds of discharges produced by the electric eel. First, there is the exploratory impulse: nature's counterpart of radar, in that when such impulse strikes an object it bounces back and discloses the presence of the object. In the murky waters of South American streams where it lives, electric ells use this echo method to find such food possibilities as fish or frogs. The second kind of shock is the lethal discharge: having detected food or sensed an enemy, the eel discharges a shock

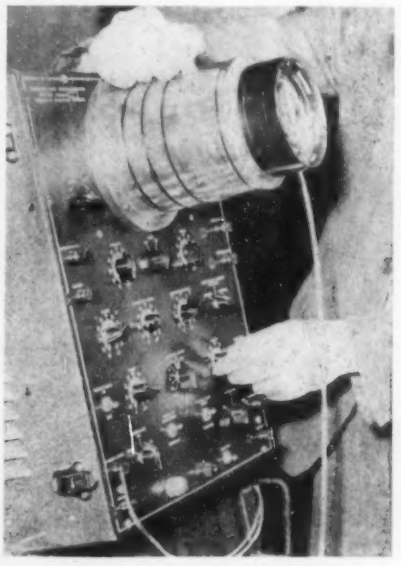


Fig. 2. The Du Mont experimental projection-type oscillograph, showing the huge lens which projects greatly-enlarged oscillograms on a screen.

of several hundred volts, stunning or killing anything in the vicinity. Dr. Coates demonstrated the intensity of the discharges by lighting 33 two-watt neon lamps arranged as the numerals "50" in keeping with the Fiftieth Anniversary theme of the evening.

Powdered Glass for Better Seals to Metal

BLOOMFIELD, N. J. — Heretofore, Kovar (the metal with the same coefficient of thermal expansion as many common glasses) has been exposed to a flame to provide the right amount of surface oxidation which is essential to a tight seal in electron tubes and other electrical equipment. Then the heat-softened glass is pressed over the still hot Kovar. The resulting joint is solid and unaffected by wide swings in temperature.

Now, however, an improved method of making Kovar seals has been developed by engineers at the Westinghouse Lamp Division. The Kovar has its surface correctly oxidized by first heating in an oven whose temperature is closely controlled. Then powdered glass suspended in a suitable liquid is applied to the cooled oxidized Kovar by ordinary spraying or dipping methods. The piece is again heated to fuse the glass. This coats the Kovar with a film of glass to which glass can be sealed in the ordinary manner, requiring simple skills.

The main advantage of the method is that it allows seals to be made under controlled conditions eliminating variations in oxidation, instead of depending upon the skill of the operator. Thus it lends itself to mass production. After the Kovar is powder-glass-coated, it can be reheated to make the glass-to-glass seal without affecting the glass-to-metal seal, allowing less-skilled operators to do the job. The method is especially suited to the making of large and complex seals where it is difficult to prevent overoxidation of the Kovar by normal methods of sealing.

EPLAB

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For the Measurement of
SOLAR RADIATION

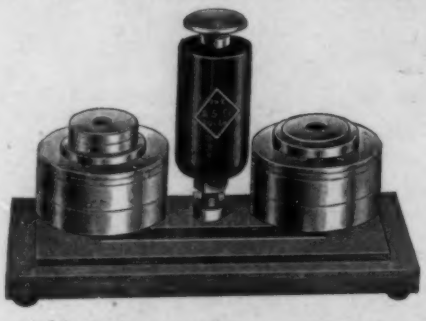
Eppley pyrheliometers are in use measuring solar radiation at fourteen out of eighteen weather stations in the United States, nine of these stations being under the direction of the United States Weather Bureau.

To industry they are an invaluable aid in the testing of paints, finishes, textiles, etc. for sunfastness.

Bulletin No. 2 On Request

THE EPPLEY LABORATORY, INC.
Scientific Instruments
Newport, Rhode Island, U.S.A.

DEAD-WEIGHT GAUGE



A portable instrument for accurately measuring gas pressures, checking static springs and other purposes where an accurate Dead Weight Guage is required.

Standard Type is available in several ranges for capacities 5 to 1000 P.S.I. High Pressure Type available in several ranges for capacities 50 to 5000 P.S.I.

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SCIENTIFIC GLASS BLOWING

(Continued from page 85)

is blown out and the straight side arm with a drawn point is sealed to the assembly. *This tube* is used for applying air pressure in blowing out the glass over the second tube. The glass holder opening is then stoppered and the seal at the opposite side is made by fusing the glass until it collapses on the tube opening. At this point it is desirable to remove a certain amount of glass covering the opening by drawing it out, after it is fused, with a small glass rod. The remaining glass is worked by repeated ex-

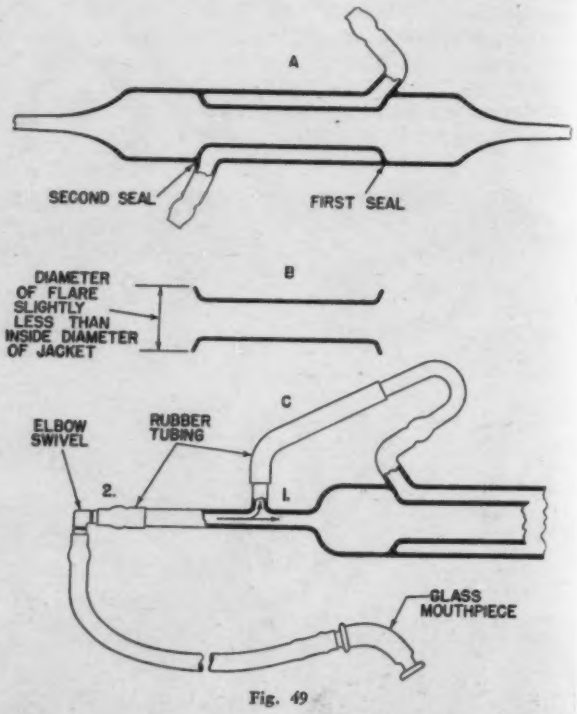

Fig. 49

panding and collapsing to insure a good seal; and the remainder is blown out and removed with a forceps. The tube on the ring seal is then cut and flared slightly at the point indicated by the dotted line, Fig. 48B. The assembly is then carefully annealed.

5. The outer tube is cut at the desired length and each end is flared, Fig. 48C. The flares should have a wall thickness comparable to that of the tube.

6. If the flares and the side tube from the ring seal are carefully made to conform to the inner jacket tube diameter, the fabricated assembly can be easily inserted into the outer jacket tube. The seal nearest the proposed side wall ring seal is completed first. The side wall ring seal is then made by sealing on the extension hose connection tube previously prepared. The entire end is carefully annealed. After the glass has cooled sufficiently for handling, the ring seal is made at the opposite end. It will be necessary to connect a blowing tube to both the side arm and the ring seal extension tube to permit blowing on both sides of the seal. The second side arm is then sealed to the jacket before the ring seal cools. Air pressure is applied through the first attached side arm. The end is then annealed, Fig. 48D.

Special Ring Seals

A condenser which is particularly useful in the fabrication of diffusion pumps is shown in Fig. 49A. The outer tube which serves as one wall of the condenser is straight; and the inner tube is flared for contact at the ring seal. The construction of this type of condenser is not difficult, except that the flares of the inner tube must be spun out to give even contact along the entire diameter of the outside tube.

1. Two side arms are prepared as illustrated in Fig. 42.

One will have to be long enough so that a right-angle bend can easily be made.

2. The one end of the outside tube is drawn to a point. Sufficient tube length must be allowed for the flared inner tube and the other end of the tube is cut squarely with an abrasive wheel or hot-wire glass cutter.

3. The successful fabrication of the two ring seals is dependent upon the flares which are made on both ends of the inner tube. These flares are made by using a triangular flaring tool. The tube is supported on a double roller and rotated with the palm of the left hand. The end of the tube is heated and spun out to almost a right-angled flare with a wall thickness comparable to that of the tube. The diameter of the flare should be slightly smaller than the inside diameter of the outer tube, Fig. 49B.

4. The flared tube is inserted into the outer tube through the open end. This end is then drawn down and opened. A tube with the form shown in Fig 49C is butt sealed to the open end. The two openings are stoppered and a blowing tube is attached to the open point which is held in the left hand. If the tubes are large it is advantageous to use double rollers. The flared inner tube is moved into position by tilting the assembly and the outer tube is heated slowly in a cross-fire or large single jet burner. The tube is rotated until the glass begins to fuse. The seal is effected by using a carbon tool and pushing the fused glass against the edge of the flare. The seal is made with a minimum of collapsing and expanding the glass so as not to disturb the symmetry of the outer tube. The seal is completed by fusing the glass sufficiently, blowing out the glass slightly and smoothing the surface with a flat carbon tool.

5. The side arm is sealed to the outer tube at the edge of the ring seal while the latter is kept hot by periodically heating the assembly. The seals are then annealed and allowed to cool.

6. The condenser is then turned end for end and the open point end is closed by fusing the glass. The side arms of the condenser and the tube handle on the other end are connected with rubber tubing and a blowing tube is attached at the end, Fig. 49C. The ring seal is completed and the side arm is butt sealed to the outer tube by the procedure used in making the first ring seal.

The Inverted Ring Seal

The inverted ring seal is useful when glass jets are required in the production of glass apparatus. The design

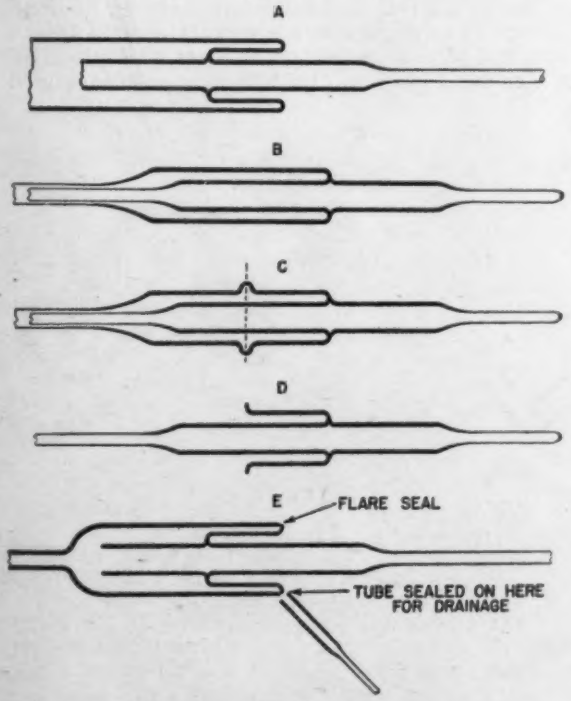

Fig. 50

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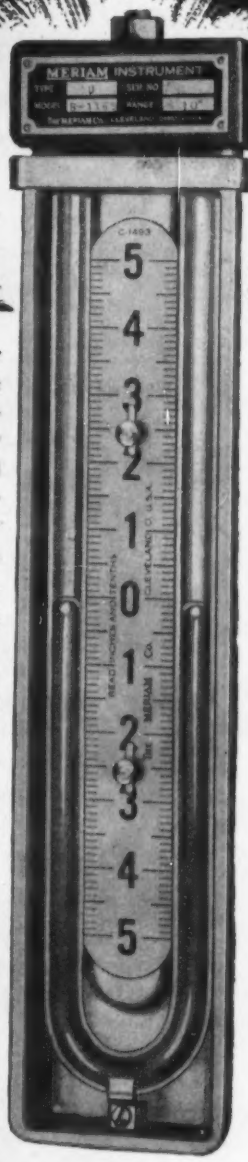

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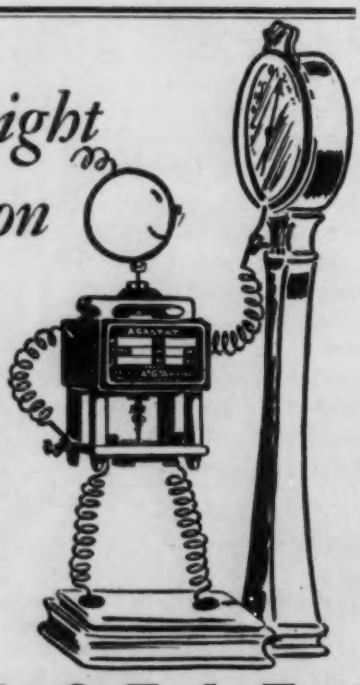

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Fig. 50A shows the two principal seals required in making the inverted ring seal.

1. A tube is drawn to a point. This tube is opened on the opposite end as illustrated in Fig. 41A. An inner tube is made as described in Fig. 41 except that a point is drawn on both ends. The inner tube point actually is centered to a certain degree by permitting it to extend into the point of the outer tube. The seal is completed as previously described, Fig. 50B.

2. The outer tube is then heated with rotation at a predetermined point and a small shoulder is blown, Fig. 50C.

3. The shoulder is allowed to cool until the glass becomes rigid and is then heated while it is rotated with a pin point burner flame at the position indicated by the dotted line. The fused glass is blown out into a thin wall and the glass is scraped away to leave a rough unfinished flare. The flare is carefully heated and spun to an even circular end with a triangular flaring tool, Fig. 50D.

4. The flare is then sealed to the outer tube. In this operation, the heat required to make the seal is sufficient to cause some deformation of the center tube, which is restored to its original shape after the seal is completed. A side arm may be sealed to the assembly if it is required, Fig. 50E.

IV. TUBE BENDS.

The fabrication of parts of glass equipment or assemblies containing sharp or sweeping tube bends requires a technique that is not developed in working with straight tubes. Practice in tube bending is recommended especially in the production of short right-angled bends.

Large sweeping bends are made without difficulty by using the ribbon burner. A mixture of air and gas provides sufficient heat to work Pyrex up to 18 mm. in diameter. The burner may be adjusted to heat tube lengths to 18 inches or more depending on the size of the burner. The tube is heated over the desired length by rotating it in the ribbon burner flame. When the glass is sufficiently softened, it is removed from the flame and the bend is made. No air pressure need be applied into the tube during the bending operation. Mandrels of different sizes are often convenient for making standard sized bends.

The production of short right-angled bends is more difficult than making large sweeping bends. Several characteristics of partly fused glass must be borne in mind when short bends are made. If a bend is made by holding the glass tube at an angle with the vertical, a slight twist will be obtained because of the flow of glass with gravity, Fig. 51A. The fused glass will tend to collapse when a bend is

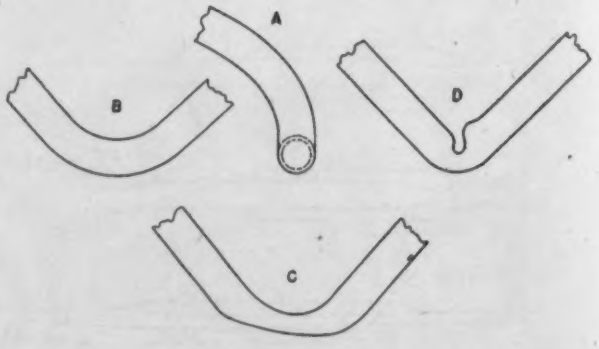

Fig. 51

made and, if air pressure is not applied at the right time, a tube with the form shown in Fig. 51C will be obtained. If an unsufficient length is heated, the bend will be too sharp and a kink will be formed, Fig. 51D. These imperfections in a bend will render it almost useless because of the danger of breaking under a small stress. The procedure in making a strong and neat sharp bend is outlined in the following steps:

1. The end of the tube which is held in the left hand is closed with a stopper. The tube is rotated in the burner flame until a section about two diameters in length is fused and slightly constricted because of the flow of glass.

2. The tube is removed from the flame and held in a vertical position with the section held in the right hand above the fused section. The other end of the tube is then moved slowly toward the horizontal with the left hand while air pressure is applied to the open end of the tube. The air pressure is released after the bend is completed and before the sides of the tube begin to bulge.

3. If the sharp bend is examined at this point, one will notice that a certain portion of the inner part of the bend has a heavy wall. The flame is directed over the entire inner part of the bend and the glass is worked to a uniform wall thickness by repeated expanding and collapsing.

A second bend which is frequently used is the right-angled bend with a radius of curvature of twice the diameter of the tube.

1. The tube end held in the left hand is closed with a stopper. The tube is then uniformly heated over a length of about three diameters.

2. When the glass becomes pliable but not fused to the extent that the tube is constricted, the bend is made by holding the tube vertical and bending the glass below the fused section to the horizontal. Air pressure is applied to keep the glass from collapsing or kinking. If the bend is made correctly no additional work is necessary except annealing the glass.

V. SPIRALS.

The fabrication of spirals from glass tubing requires less skill than one would suppose. In small tubing, the ratio of wall thickness to diameter is greater than that of large tubing; and consequently it is only with tubing of larger diameters that more care must be taken in making spirals. Longer sections must be softened by large bushy flame and the tube must be carefully bent into form or wrapped around the mandrel, so that the tubing is not appreciably flattened.

A 40" length of tubing with 1-mm. wall thickness and 3-mm. bore (5-mm. outside diameter) is best used for the first exercise in making spiral. One end of the tube is closed with a stopper.

1. This tube is bent sharply at a right angle about 6" from the open end; position 2, Fig. 52A. This length is to serve as an end of the spiral.

2. The tube is then heated at position 4, Fig. 52A, and bent toward the operator in another right-angled bend, the distance 2 to 4 being the radius of the spiral.

3. The tube length 4 to 3, Fig. 52B, is required for the fabrication of the spiral. From the proposed coil diameter, the length of glass required for the completion of the spiral can be calculated. The section 1 to 2 is held in the left hand at an angle and heated in the burner flame, while the long section 4 to 3 is supported with the right hand. A portion of the tube is heated near 4, Fig. 52C, by both rotation and a movement along the axis of the tube. The major portion of the heating should always be on the outer side of the tube.

4. As the glass becomes plastic, section 1 to 2 is held horizontal and section 4 to 3 is bent slowly to form the section of the circular bend for the first spiral, Fig. 52B.

5. The tube is then heated beyond the bent portion until the glass is softened. This section of the tube is formed into an arc of the circle previously started. This step is repeated until the first turn is completed. All bending is done outside the flame and observation from different angles will assist in the alignment of the tubing.

6. After the first complete circle is made truly axial to the tube section 1 to 2, further turns are made much more easily because the softened section is always bent into coincidence with the outline of the turn below it, Fig. 52D. The spacing between successive turns should

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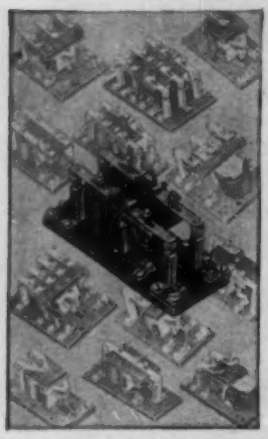

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be constant as shown in the side view of Fig. 52D. Spirals are often required as the inner tubes of condensers and therefore the ends must be aligned as section 1 to 2 of Fig. 52D. The tube ends are flared sufficiently so that good ring seals can be made.

More precision is possible in the fabrication of spirals by using a mandrel for forming the glass. Various sizes of mandrels can be made of metal pipes which are suitably mounted, but a great deal of success has been obtained in using glass tubing. The glass-tube mandrel is simply a glass tube wrapped spirally with asbestos tape.

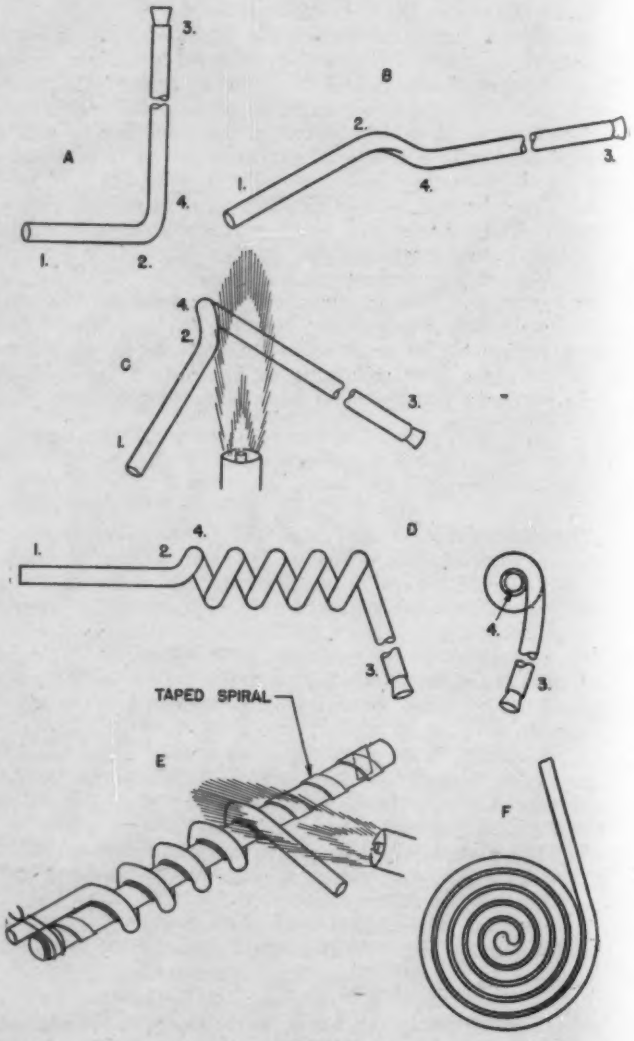


Fig. 52

1. The tube is heated at a section about 6" from one end and bent in a right angle. This tube is tied to the wrapped mandrel, Fig. 52E. The glass is then heated in short sections of about 1" in length and the tube is wrapped around the asbestos-covered glass mandrel. The tape serves as a guide for the spacing of the spiral turns.

2. The spiral and mandrel are allowed to cool and the former is removed by wetting the tape with water.

The flat spiral, Fig. 52F, is sometimes required in the fabrication of glass equipment.

1. A required tube length is heated at a section 6" from one end. The glass tube is bent in a short right angle.

2. The glass is then heated at the right angle and the inner turn of the spiral is started by bending the tube in a circle around the short section that is used as a handle.

3. The spiral is continued by repeatedly heating short sections of the tube and bending it around the inner spirals.

4. After the flat spiral is completed, the tube is cut away at the center of the spiral with the burner flame.

VI. CLOSED GLASS TUBING CIRCUITS.

Close observation of fabricated glass apparatus will show that unnecessary seals in conspicuous places detract from the appearance of the finished equipment. There was a time when it was necessary to make extra seals in glass equipment because of the high coefficient of expansion of soft glasses. No amount of speed could overcome fractures in attempting to complete two or more seals in one operation. Now, owing chiefly to the rugged shock-resistant qualities of Pyrex glass, it is possible and often convenient to assemble any number of parts.

One important thing must be remembered in making closed glass tube circuits: when two or more seals are made at the same time, each must actually be partly completed. Instead of fusing the glass so that it will just stick together when one glass tube is pressed against the other, the opening in the glass is heated until it is fused to yield a butt seal which requires only work in making the seal smooth. This seal may be left as one performs the same operation at another point in the circuit. When the circuit is completed, each seal can be worked until smooth without the danger of fractures at the seal.

An illustration of closed circuit seals is given in Fig. 53A.

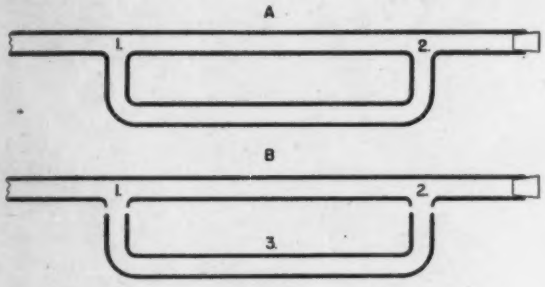


Fig. 53

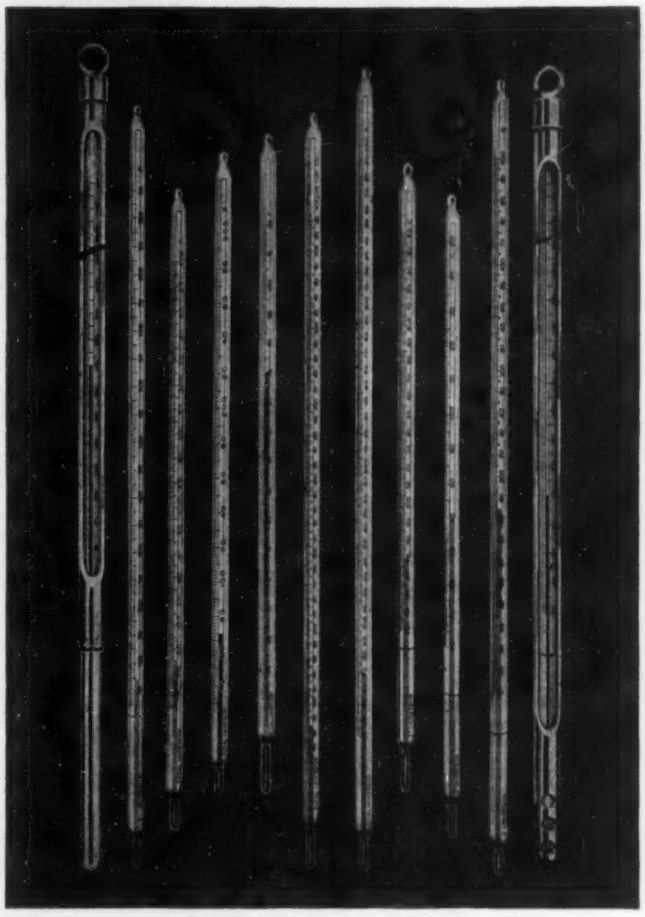
Seals of this nature are necessary for the fabrication of McLeod gages, manostats, flowmeters, etc.

1. The straight tube, Fig. 53B, is opened at points 1 and 2 by fusing the glass and blowing it out in the steps outlined for preparing an opening in the wall of a tube.
2. The second tube is bent at right angles at each end. The glass at each end is then cut with the burner flame and each end is slightly flared, Fig. 53B, tube 3.
3. The end of tube 3 and the opening at 2 are heated until the glass begins to fuse sufficiently to give a leak-proof seal when the two are pressed together.
4. The seal at position 1 is then started. The main difficulty which will be encountered at this point is to fuse the glass around the entire circumference of the openings. This is necessary or small pin-holes will be formed because of uneven heating. After the fused glass is pushed together, the seal is completed by the procedure recommended for a side tube seal. The glass is then annealed.
5. The first seal is warmed slowly and is completed by the technique of making side seals. The glass is carefully annealed after the seal is smooth.

Regardless of the shape of the parts to be joined, the only critical factors are the positive matching of tube openings and production of partial seals which are flowed together by pushing together the two fused ends.

Torch Sealing

All glass equipment which is mounted on racks must frequently be built in several sections or parts, each of which must be sealed in place on the rack. Hand torches instead of the bench burner must be used. The glass is heated by moving the hand torch flame around the glass tube ends. It is just as important to develop the skill in torching technique where the glass is uniformly heated around the glass tube as is the rotation of glass in the burner flame in hand work. The flame is kept perpendicular to the glass tubes and is moved completely around the circumference. Overlapping or underlapping in the heating is not permissible. Over-



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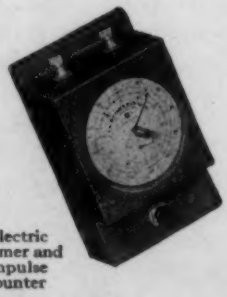

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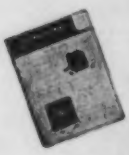

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lapping creates a hot spot in the glass which is more easily blown when pressure is applied, and underlapping will leave a partially fused section which cannot be worked satisfactorily.

A good deal of planning is necessary when an intricate glass assembly is to be mounted on a rack. One important thing to remember is that seals are more easily made when the glass tubes are in a vertical, rather than a horizontal position; and seals so made are superior, both in appearance and durability. All bends should be smooth and the tubes should be positioned for an adequate number of clamps. All glass parts should be so placed that a torch can conveniently be used if repairs are necessary. An example of a neatly arranged assembly is shown in Fig. 54.

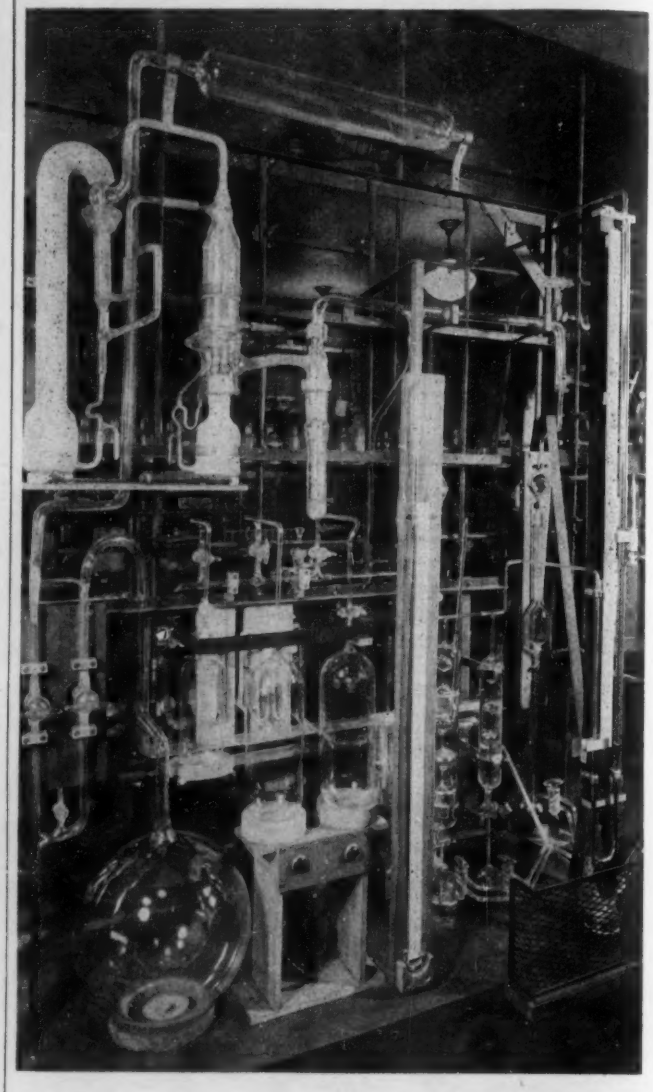

Fig. 54

The procedure in making a vertical tube seal is illustrated in Fig. 55. The operation has been simplified for convenience of description. In actual practice the two tubes could be ends of two separate glass assemblies.

1. The ends should be perfectly square. The upper tube is clamped rigidly on the rack and has a blowing tube attached at some convenient point. The bottom tube is closed with a stopper and is held or loosely clamped directly under the upper tube. A gap of about 1/16" is left between the tubes, Fig. 55A.

2. The two ends are heated by moving the hand torch flame around the tubes until the glass is fused but not appreciably deformed. The bottom tube is then lifted until a complete contact is obtained around the circumference of both tube ends. The glass is allowed to cool slightly. The

glass just above the temporary seal is heated by moving the torch flame around the tube. As the glass begins to fuse the lower tube is pushed upwards until sufficient glass is gathered to give a thickened circular band around the tube, Fig. 55B.

3. The glass is allowed to cool until it supports the weight of the lower section. The glass tube assembly is then heated uniformly just below the seal and drawn to a thin wall, Fig. 55C.

4. The seal is then completed by heating the thickened and thin sections at the same time. As the glass is fused and worked, the glass in the thickened portion will gradually flow with gravity and when the seal is completed it has the form as illustrated in Fig. 55D. The tubing is slightly reinforced at the seal.

The Litton hand torches described and illustrated in Chapter I are recommended for sealing tube assemblies. The

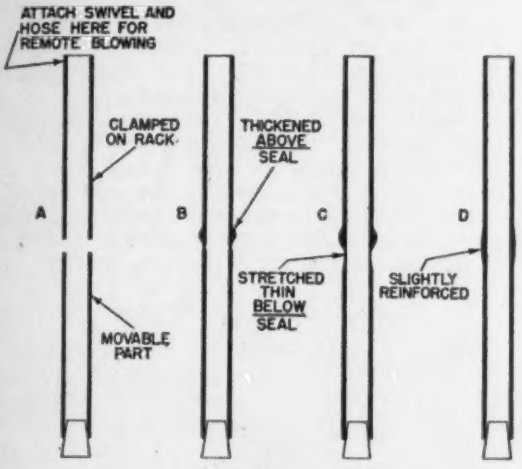

Fig. 55

larger torches are useful in sealing tubing with large diameters.

Vertical capillary seals should be made by using a small Hoke Jewel torch by the procedure as described for ordinary tube seals. The inside bore should be perfectly aligned when first contacted. The seal should be completed with a minimum of enlargement of the bore by blowing.

Horizontal seals on fixed tubes cannot be made by fusing the glass around the circumference of the attached tubes because the glass will flow with gravity. The only procedure which is recommended is the spot fusing technique. The glass is fused and the tubes are pushed together. The rough seal is allowed to cool until the glass becomes rigid. The seal is then completed by successively fusing short segments of the circumference and working each until the glass is smooth. Each completed portion is allowed to cool before the next is fused.

No matter how careful one may be, there are times when small pin-holes appear on a torch seal. The only satisfactory way the hole can be closed when the tubing is clamped in position, is to spot a small amount of fused glass over the opening. A small, thin glass rod is used. The glass at the end of the rod and that at the seal are fused sufficiently so that the glass will stick when touched to the tube. The rod is then cut by the burner flame as close to the seal as possible. The seal is then worked until the glass is smooth.

If instead of a pin-hole a small gap develops at the seal which cannot be closed by spotting with a glass rod, a thin glass ribbon can be spotted over the opening. The ribbon is made by flattening a fused glass rod with a forceps and then fusing the flat glass and pulling it to a glass ribbon.

When seals are made on a vacuum system or on a complex gas reactor system, it is always advisable to use a drying tube with the blowing tube, Fig. 56. Any suitable desiccant which will eliminate moisture is satisfactory.

Cutting out or removing sections from an all-glass system is a delicate operation. If the tubes are small and flexible

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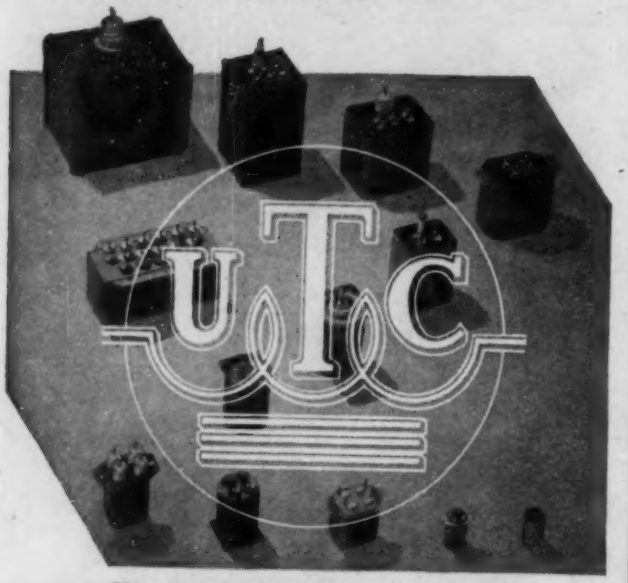

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the glass can be cut by first marking the glass with a file, wetting the mark and breaking the tube by the procedure outlined in the first chapter. However, on tube sizes above 18 mm. it is necessary to make a file mark about a quarter-inch long. The end of a glass rod is heated until the glass begins to flow and is immediately touched to the center of the mark after the latter is wetted with water. Usually, the expansion of the tube caused by the heat from the hot

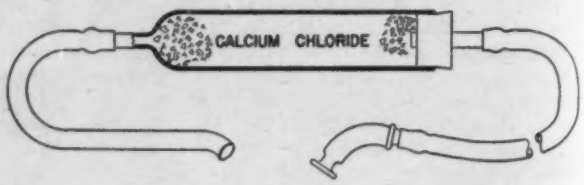

Fig. 56

rod will cause a crack that will encircle the entire tube. If the crack does not completely encircle the tube, it may be led in the proper direction by touching the point of a hot glass rod about ¼" beyond the end of the crack. If the crack breaks away and begins to run lengthwise in the glass of the tube, it must be stopped before another attempt is made to break the tube. The extension of the crack is stopped by slowly warming the tube beyond the end of the crack. As the temperature of the tube increases, the flame is brought closer to the cracked area. The glass will fuse together if it is not heated too rapidly.

Electronic Welding of Glass

Hand torches or blast burners when used in sealing heavy Pyrex tubing or pipe have one principal disadvantage. The glass is heated through the surface and, to fuse the tube end sufficiently for sealing, portions of the surface are often overheated. Volatile constituents of the glass are lost because of the high temperatures in the glass surface.

Electronic heating is becoming important for internal heating. This form of heating has been performed with high-frequency current through dielectric loss between capacitor plates or by the use of special gas-flame conducting electrodes. The latter method of internal heating is described by E. M. Guyer.[1]

Gas-electrode sealing is comparable to resistance welding. The gas-flames at the tips of the electrodes have two principal functions:

1. The glass is preheated to a temperature where it ceases to be an insulator and becomes a conducting medium.
2. The flames provide a conductive path for the heating current.

The technique of using these electrodes is similar to the torching technique previously described. The flames are directed against the glass and the temperature is regulated within the glass by increasing or decreasing the distance between the glass and the tip of the electrode.

Since radio high-frequency generators are expensive, investment in such equipment would be warranted only when considerable work is done on equipment requiring internal heating.

To be continued

[1]E. M. Guyer, *Electronics*, Vol. 18, No. 6, 1945, page 92.

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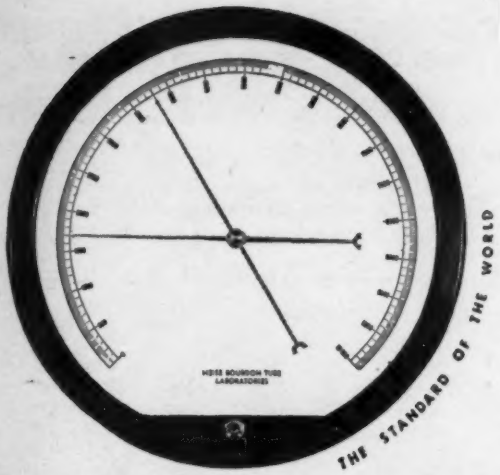

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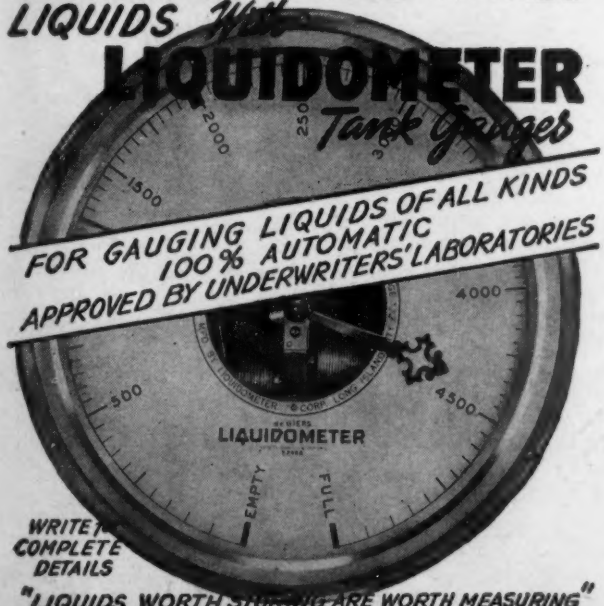

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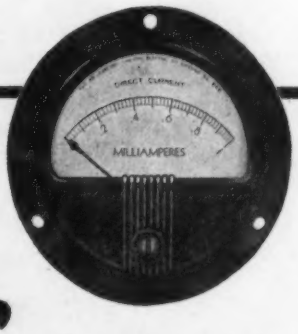

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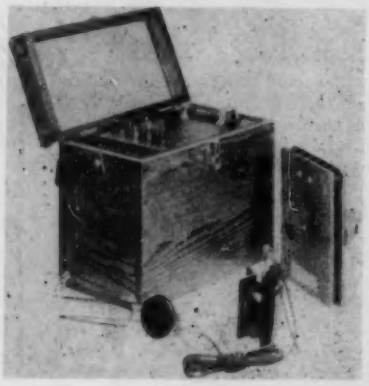
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Buried Cable and Pipe Locator and Tester

New "Stewart Cable Tester & Locator Combined" combines means for the precise location and depth of buried pipe and cable, with "Stewart



Cable Tester" which provides means for location of shorts, crosses, grounds, and wet spots. In simple operation it tells where cable or pipe is buried, and how deep. It also has a lamp circuit for checking all connections after test has been set up. It is especially valuable for checking depth of cable at river crossings, can also be used to rechart a town or district where records have been lost. Instrument is portable, ruggedly built and encased for rough use and weather. Size: 12½" × 7¼" × 11" high. Weight: approx. 22 lbs., including head phones and neutral exploring coil, and fish scale exploring coil.—*W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Illinois.*

Pulsing Control Drive

New "Yardeny Pulsing Drive" provides single-knob control of any type of reversible motor. Direction and extent of motor motion are under complete control of single knob. Motor may be continuously rotated or moved in

small increments. Control action is as follows: Slow clockwise rotation of control knob results in a corresponding motor motion in small increments. Slow counter-clockwise rotation of control knob causes reverse motor rotation in small increments. Either of these operations permits controlled mechanism to be spotted "with the highest degree of accuracy," it is said. Rapid rotation of control knob causes faster motor motion and more extended travel. Thus, features of fine and coarse control are incorporated in this single-knob control. By depressing knob and turning it slightly right or left, continuous forward or reverse rotation of the motor can be accomplished. "Yardeny Pulsing Drive" works on all standard currents and frequencies. It is said that extent of fine and coarse control provided by unit can be made to suit every purpose in a manner that permits quick approach and precise positioning of the controlled object. New drives are suitable for inclusion in all existing controlled motor devices and offer advantages for new design projects. Recommended applications include precision control of valves, flaps, radio tuning elements, cranes, lifts, rollers, presses, machine tools, mixers, etc., requiring more precise and more flexible control than is afforded by push-button methods of control.—*Yardeny Engineering Co., 105 Chambers St., New York 7, N. Y.*

Stabilized Low-voltage Rectifiers

New stabilized rectifiers with *low*-voltage high-current output are said to represent an advance. (High-voltage low-current rectifiers with electronic stabilization have been known for many years.) A typical unit is rated at 200 amperes, voltage range zero to 3 volts. Any voltage selected in range is maintained to within 50 millivolts over load variation from zero to 200 amperes, and with line voltage variation of ±10%. Voltage stabilization system includes motor-driven "Powerstat" and simple electronic pilot device. Principle is widely applicable to larger or smaller rectifier units. — *Green Electric Co., 130 Cedar St., New York City.*

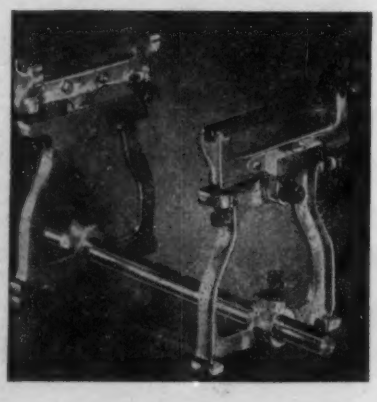
Hand Pyrometer for Non-ferrous Molten Metal

New "Xactemp Pyrometer," for measuring temperature of molten nonferrous metals, is of cast aluminum and brass construction, with 43" stainless steel extension and a standard 7" Marshall tip which permits true readings to be taken below the surface of the metal. Indicator is of medium resistance, not affected by thermocouple length, and yet travels across the scale

rapidly enough to follow the most sensitive thermocouple. It is provided with an Alnico V magnet and has a 3½" scale reading from 50 to 2500°F. This instrument is always ready for use as it needs no preliminary adjustments. It is claimed that its accuracy makes possible quality control and elimination of blowholes, burnouts, sand infiltration and other flaws due to incorrect temperature.—*Claud S. Gordon Co., 3000 S. Wallace St., Chicago, Illinois.*

Static Balancer

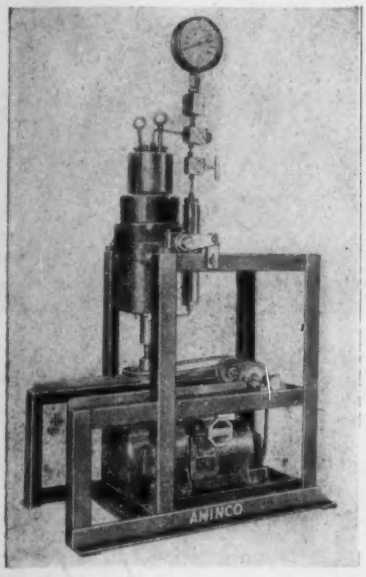
New precision-built static balancer has a number of distinctive features that make it a useful addition to shops where rotating parts must be put in static balance. The 9" model illustrated has a finger-tip span adjustment up to 9½". New balancer is said to be compact, strong and rigid, of utmost simplicity, yet accurate to the finest degree. Because there are no movable parts, there is nothing to get out of order. Balancing surfaces are deep hardened and ground for accuracy.



Particular attention is called to the spirit levels which indicate horizontal position of the rails. Frames are of cast aluminum, highly polished. Supporting capacity of illustrated model is 100 lbs.; shipping weight is 2 lbs. It is claimed to be ideal for balancing motor armatures and small rotating parts. Two larger models are available: 24" and 36" sizes.—*Samuel S. Gelber, 34 S. Jefferson St., Chicago 6, Illinois.*

Tilting-type Stirring Autoclave

New laboratory stirrer-type superpressure assembly has a capacity of 845, 1410, 2960, or 1780 ml., for operation at pressures up to 10,000 lbs./in.^{2}



and at temperatures up to 750°F. Other sizes are available. Means are provided for tilting the reaction vessel (autoclave) and its heating jacket into a position whereby its contents may be poured or scraped out, and its interior more easily cleaned. Apparatus is equipped with a thermowell, a stirring-type agitator, a pressure-lubricated stuffing box, an electric heating jacket controlled by a three-heat switch, a safety blowout assembly, an 8" hydraulic pressure gage, and necessary valves and fittings. Agitator, whose shaft enters through bottom of autoclave, is driven by a variable-speed motor. Both motor and heater are for operation on 115 and 230 volts, 60 cycles, single phase.—*American Instrument Co., Silver Spring, Md.*

Controlled-atmosphere Laboratory Furnace

New "Lab-Type" heat-treating atmosphere electric furnace fills need for standard laboratory equipment for appraising effects of various atmospheres on metals at elevated temperatures. Inside diameter of retort is 4½"; working space 6" deep. Temperatures up to 1825° F. inside retort are measured by a thermocouple. Another thermocouple measures temperature inside furnace chamber. By substituting retort for a high-temperature alloy pot, furnace can be quickly converted for salt bath or

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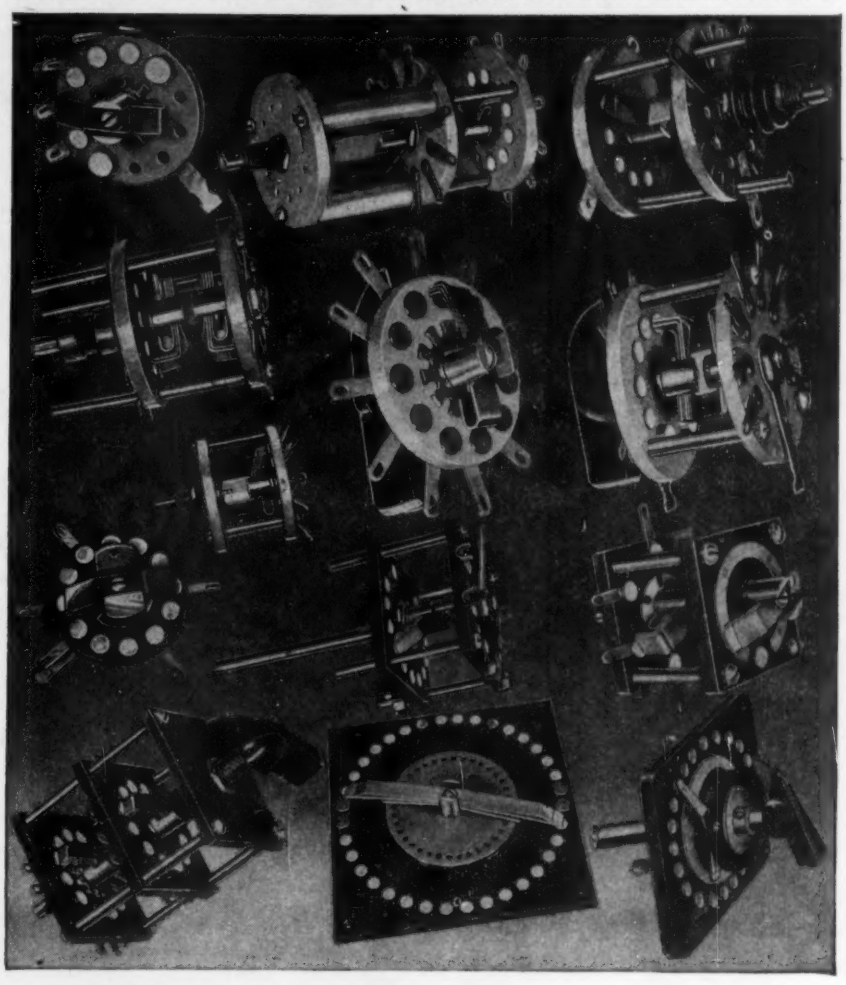

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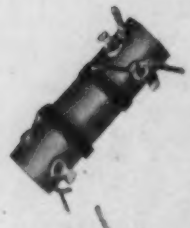

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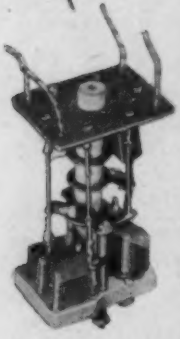

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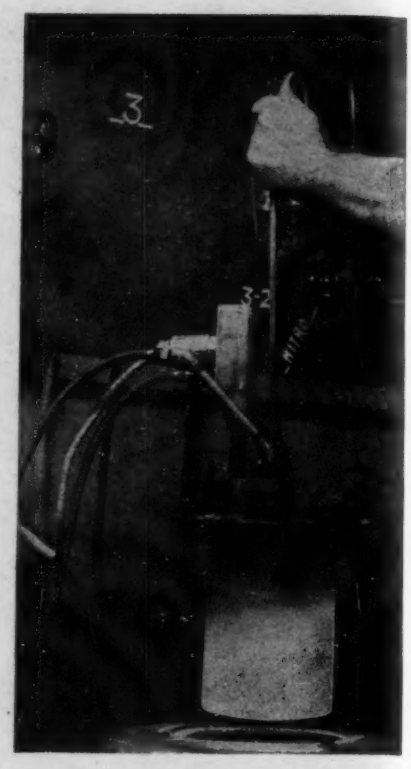


lead bath immersion, tempering, hardening, and annealing, cyaniding and aluminum heat-treating. By removing alloy pot, empty-furnace chamber can be heated up to 2000° F. and used for straight heat treating, etc. Supplied for 115- or 230-volt 60-cycle a.c., complete with built-in transformer, relay, and thermocouple for heating chamber. Manual or automatic controls, recording devices, and other accessories furnished as desired.—*Boder Scientific Co., 907 Penn Ave., Pittsburgh 15, Pa.*

Pressure-controlled Switch

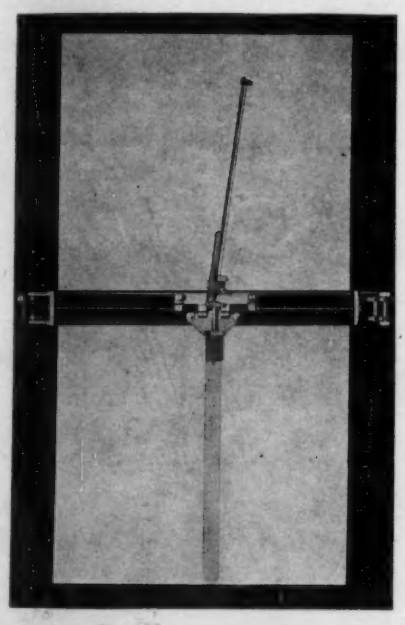
New pressure-controlled "Mu-Switch" provides a compact (1" × 2 15/16" × 3 5/8" over-all height) and vibration-resisting means for regulating

or indicating fluid pressures, or for controlling electric circuits whose operation is to be coördinated with changes in the pressure of a liquid or gas. Electric control element is a standard s-p. d-t. "Mu-Switch." For

industrial applications, switch is furnished with a "Type M Mu-Switch" rated at 15 amperes 125 volts a.c. to 2 amperes 600 volts a.c. or ½-hp. at voltages up to 460 a.c. For aircraft and other low-voltage d.c. applications, pressure switch is furnished with a standard "Type A Mu-Switch" having a maximum current rating of 25 amperes at 28 volts d.c. Hub for electrical conduit connection has an internal ½" pipe thread. Pressure-sensitive portion of the switch assembly consists of a metal bellows soldered into a brass tube securely attached to housing. Upper end of pressure chamber has a standard ½" pipe thread for attachment to pressure line. This unit can be furnished for operation with a differential of 5 to 15 lbs./in.² at nominal ratings of 10 lbs. to 120 lbs./in.². Pressure chamber is made of a corrosion and heat-resisting material, and unit can be safely operated at temperatures up to 300°F. — *Mu-Switch Corporation, Inc., 380 Pequit Street, Canton, Mass.*

Device for Perspective Drawing

New "Stereograph" perspective drawing machine enables draftsman to produce a stereoscopic pair, showing length, width and depth or, if desired,



a single perspective drawing; thereby reduces time and cost in making perspectives. In addition, they can be made to scale. With this instrument it is not necessary to use ordinary equipment of the drawing board to find vanishing points. Device is said to be valuable for solving problems in geometry and equally ideal in descriptive geometry. It can produce third-dimensional effects, also to show internal construction of highly complex mechanisms. Instrument is constructed of duralumin, with high-carbon steel for guides and rotating members. It is 32" long and 3¼" wide, mounted between two drawing boards. At the top is a hair-line point finder 20" long and at the bottom is a 20" straight-edge by means of which the operator can make the per-

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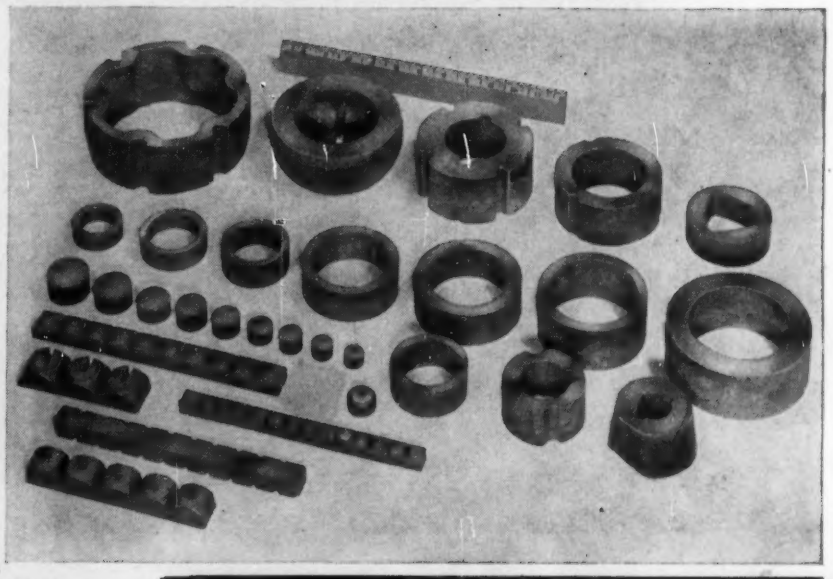

The speaker magnets illustrated above are representative, yet are just one type of permanent magnets described in the new 24-page Arnold bulletin, "Permanent Magnets for Industry."

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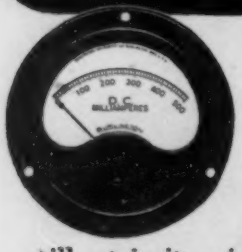

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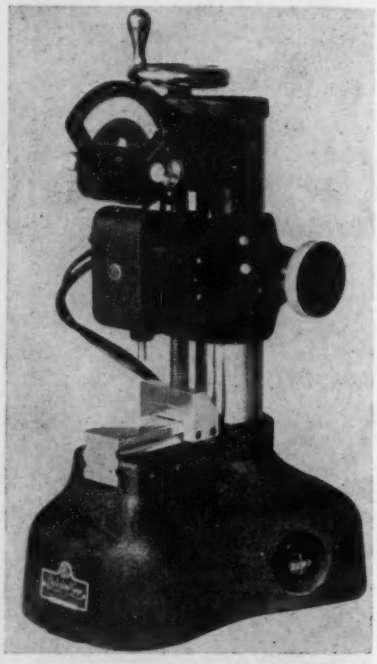
spective drawing. Two drawing boards are both 23" × 31", mounted on square metal tubing. Dowel pins for positioning these boards can be removed with the drawing for additional work and replaced in exact register. Mechanism is said to be extremely simple, yet constructed with such precision that accuracy is finer than the human hand in drawing a pencil line. The stereo-pairs which are produced are called "Stereographs" and can give such three-dimensional understanding of a device that the necessity of a mock-up is said to be obviated and similarly the engineer or designer could visualize the complete object thereby enabling him to check and correct the original design. Variables which are shown as a family of curves, such as required in disclosing vacuum-tube characteristics, can be shown as continuous "space curves," or three-dimensional graphs. The space curves would give a new approach to the representation of data in electronics, optics, mechanics and chemistry.—*Pomeroy Stereograph Co., Inc., 1783 E. 11th St., Cleveland, Ohio.*

External Comparator with Limit Lights

New "Electrolimit Comparator" combines "P&W Electric Contact Unit" with "P&W Electrolimit Head" into an assembly for accurately detecting prod-

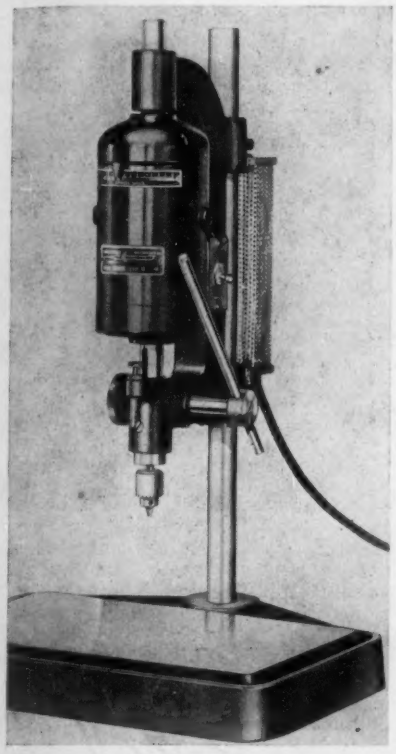


uct limits. Little neon tube undersize and oversize lights are positioned at the sides of indicator requiring only one line of vision for both the lights and the indicator. Operator knows in an instant, by watching limit lights, whether part is undersize, oversize or within limits. Minus light on left, being normally on, will remain so when part is undersize. When part is oversize, minus light will be turned off and plus light on right will flash on. When part is within determined limits, both lights will remain off. Should operator desire to make an actual size reading of any part being checked, it is only

necessary to slow up the high-speed gaging operation sufficiently to read the indicator.— *Pratt & Whitney, Div. Niles-Bement-Pond Co., West Hartford, Conn.*

Instrument-shop Drill Press with Automatic Speed Control

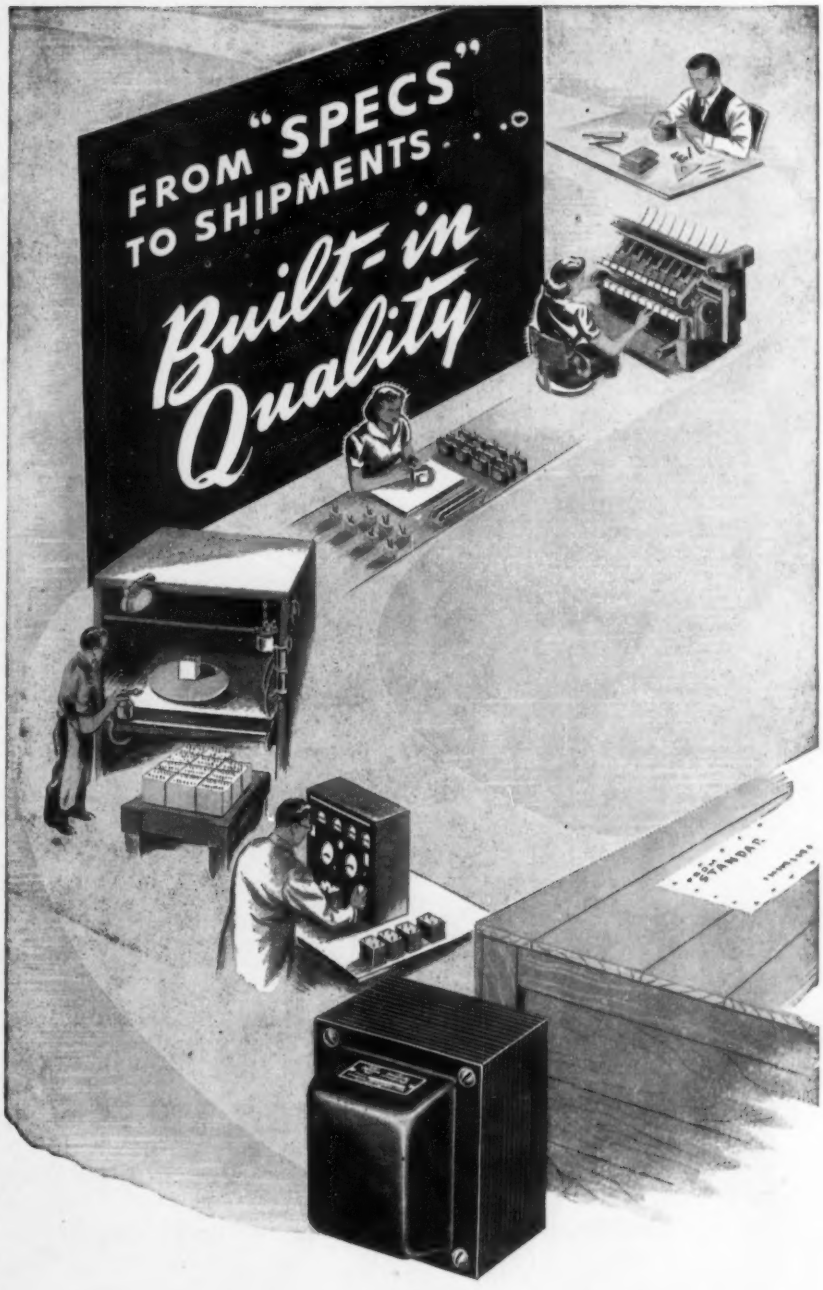
New "Model 105" drill press has unique design features, among them: (1) chuck, motor armature and gov-



ernor are all mounted on a single spindle; (2) instead of rheostatic speed control there is a speed control instrument in the form of an adjustable centrifugal governor; (3) spindle speed is set by lever-and-scale on front of housing and desired speed is maintained with or without load. Either a ½-hp. or a 1/10-hp. motor is available, also a choice of spindle speed ranges to 15,000-rpm. maximum. — *The Electro-Mechano Co., 261 East Erie St., Milwaukee 2, Wis.*

Gas Alarm System

New "Davis Remote Head Gas Alarm" is of the AFML-approved type which will visually and audibly indicate the presence of combustible gases or vapors before a fire or an explosion could take place. Its advantages are said to be (1) Analysis of the gas takes place in the remote head. Thus, indication is instantaneous. (2) Remote head being explosion-proof, can be placed in the gaseous atmosphere. This permits analysis of the gases as they exist. Some gases and vapors, if drawn any distance through a tube would condense, hence, inaccurate readings. (3) Any number of analysis heads may be employed, each independently of the others, each calibrated for individual gas. Operation of unit with any number of analysis heads takes place at one



"The whole is equal to the sum of all its parts"—Elementary? Of course—as simple and unchanging as all great principles. This axiom is a fundamental manufacturing creed at Stancor. We know the established excellence of Stancor Transformers is vitally dependent upon the perfection of each successive manufacturing step—from engineering considerations of individual specifications—through coil-winding, laminating, assembling, finishing, testing—and, finally, to careful packing for shipment.

All individual manufacturing operations have one common denominator — QUALITY — uncompromising, changeless QUALITY that continues to prove — "IN TRANSFORMERS, STANCOR GIVES MORE."

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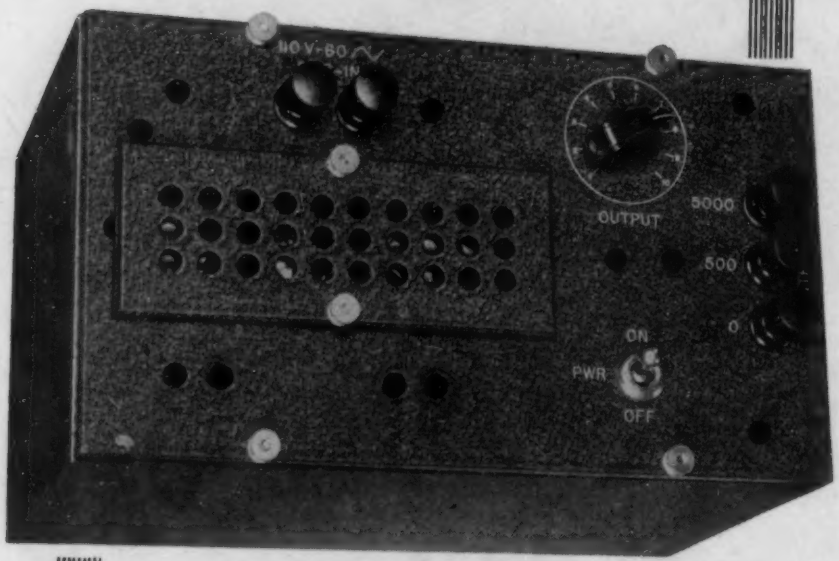
Now . . . a compact audio signal source for laboratory and production test applications



The Type MR-1000 is a compact source of audio frequency power producing up to 35 MW of signal energy at output impedances of 500 or 5000 ohms.

The distortion at maximum output is less than 2% over all.

The built-in attenuator features an arbitrary scale of 1 to 10 units.

The Type MR-1000 operates from a standard source of 110 volts, 60 cycles.

The case, panel and subchassis are 1/4" aluminum. A removable ventilator panel at the top permits easy tube replacement.

Using a new type of oscillating amplifier circuit, this unit maintains an output frequency of 1000 cycles at plus or minus 1 cps over 24 hours and will operate continuously for 720 hours with a variation of less than 4 cps.

OPERATION:—The MR-1000 serves to replace tuning forks and offers a source of audio test energy for bridges, etc., and can be substituted in existing test positions without wiring changes. The MR-1000 can be furnished at frequencies other than 1000 cps at slight additional cost.

SIZE:—6¼" deep x 5¾" high x 9¼" long.

WEIGHT:—13½ lbs.

PRICE:—$149.00 f.o.b. Chicago. . . . Guaranteed 2 years.

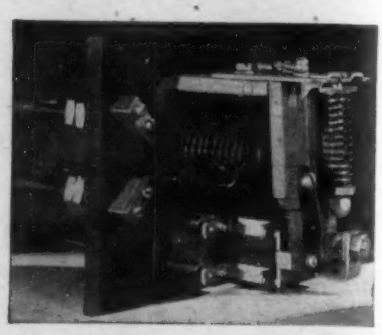
TELEVISO PRODUCTS CO.

7466 IRVING PARK ROAD CHICAGO 34, ILLINOIS

point. (4) Filament blow-out signal gives operator a visual and audible indication if any head is inoperative. The other heads continue to give protection. Ventilating fans may be started, automatically, or machinery may be stopped.—*Davis Emergency Equipment Co., Inc., 80 Halleck St., Newark 4, N. J.*

Magnetic Overload and Jamming Relays

New "Type AYJ" relay for d-c. operation is designed to provide almost instantaneous magnetic overload protection on general-purpose and mill



motor applications, and to prevent damage to hoist, windlass and capstan equipment when the load or cable jams on marine control. Single-break normally-closed main contacts and double-break auxiliary contacts are suitable for carrying 5 amperes continuously and for interrupting a d-c. inductive coil load of 150 v-a. maximum. "Type AYJ" relays are operated by a series or copper strap wound type of coil. Coils and coil studs are available for currents ranging from approx. 75 to 625 amperes. Coils and auxiliary contact parts are insulated from the relay frames for 600 volts. Relays are of unit construction with a knife-edge bearing between armature and the frame, are completed assembled and tested at factory before shipment. Ground armature and frame surfaces are plated with hard chromium for protection against corrosion and wear. —*Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Penna.*

Exposure Meter

New "Type DW-58" splashproof exposure meter is adapted for correct exposure readings for camera, in darkroom, and for balancing light in studio.

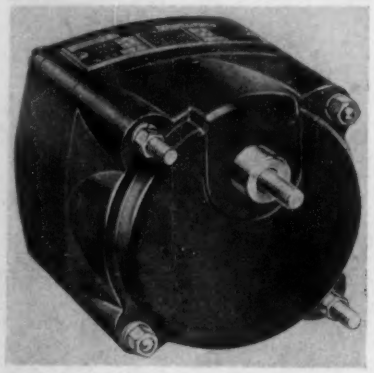
By utilizing a new internal-pivot element, weight is reduced approx. 22% with a gain in over-all sturdiness. Although slightly more streamlined, new meter resembles pre-war model. However, case has been completely redesigned, rendering instrument dust- and moisture-proof and having zero set on front. Directional hood has also been redesigned, is finished with non-reflecting surface on inside for greater accuracy in measurement. Military requirements for high-shock instruments are incorporated in design and construction.—*Meter & Instrument Div., General Electric Co., West Lynn, Mass.*

Tungsten Carbide Thread Plug Gages

New thread plug gages of tungsten carbide are available as follows: Immediate shipments from stock on National fine and coarse series, Class X, standard GO member sizes as: #5-40, #6-32, #10-24, ¼"-20, 5/16"-18, ⅜"-16, 7/16"-20, ⅝"-18, #8-32, #10-32, ¼"-28, 5/16"-24, ⅜"-24 and ½"-20. Two to four weeks deliveries on other standard GO and NOT GO members. Four to six weeks deliveries on Specials which conform to American National Form single straight lead with threads per inch not exceeding National Fine Series, Class X.—*The Sheffield Corp., Dayton 1, Ohio.*

Miniature Motors

Two new types of "Ostermotors" are announced. They are small precision capacitor synchronous and induction



motors for instrument and control applications where constant, unvarying performance is required. Output range 1/1000 to 1/2000 h.p. They are available in 4 pole or 2 pole types, with or without gear reduction. Weight of gearmotor unit 33 ounces.—*John Oster Mfg. Co., Racine, Wisconsin.*

U-v. Lamp for Dials and Knobs

New 6-watt 8½" × ⅝" fluorescent lamp produces ultraviolet rays whereby dial markings and control knobs are made to glow in vivid colors. Although new "black light" lamp was designed chiefly to improve radio dial lighting, it is expected to find applications in television and other cathode-ray tube applications where it will cause control knobs and dials to fluoresce with easy visibility and minimum interference with the CRO screen image. The u-v.

Manufacturers!

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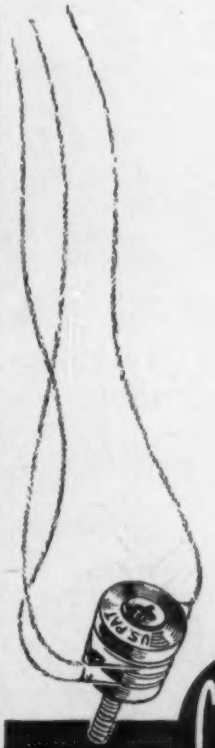
You can stop "guessing" about Rectifiers.



It's another "first" for Conant. Now, you can get, free of charge, a "New Rectifier Replacement Guide" for most test equipment. You can know, at a glance, the correct type and size rectifier for any instrument installation or repair job. Write for your "Guide" today.

RECTIFIER SHIPMENTS PREPAID

Beginning January 1, 1946, every order (large or small) for Conant rectifiers will be shipped to you *prepaid*. It's just another trouble-saving, money-saving Conant service.

REMEMBER, over 90% of all instrument rectifier requirements can be served by Conant's 4 basic assemblies in 3 series (500, 160 and 160-C). You can Count On Conant.

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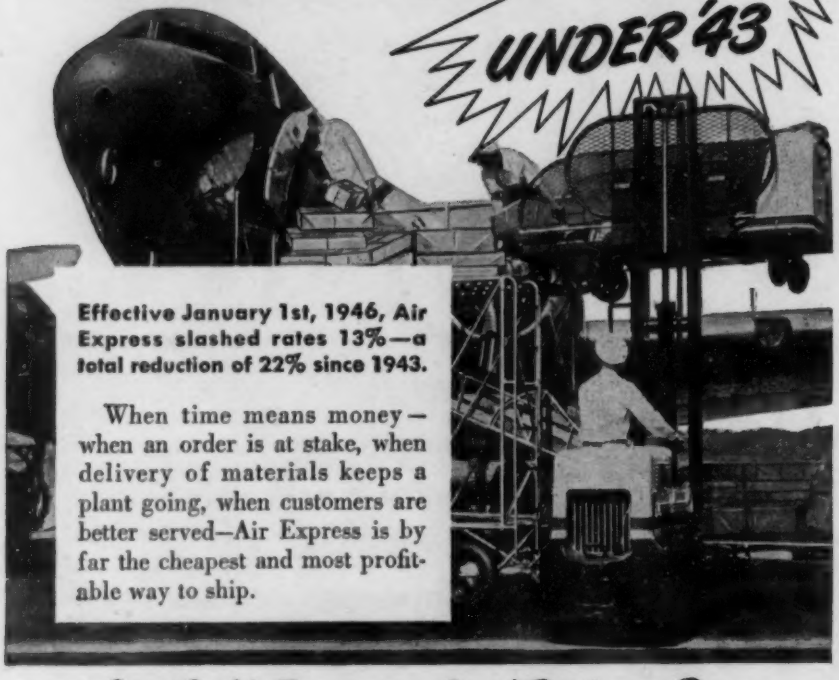

Effective January 1st, 1946, Air Express slashed rates 13%—a total reduction of 22% since 1943.

When time means money—when an order is at stake, when delivery of materials keeps a plant going, when customers are better served—Air Express is by far the cheapest and most profitable way to ship.

Specify Air Express—a Good Business Buy

Shipments travel at a speed of three miles a minute between principal U. S. towns and cities, with cost including special pick-up and delivery. Same-day delivery between many airport towns and cities. Rapid air-rail service to and from 23,000 off-airline points in the United States. Service direct by air to and from scores of foreign countries in planes made in America, operated by American personnel and flying the U. S. flag.

HERE'S HOW LITTLE IT COSTS (U. S. A.)					
AIR MILES	2 lbs.	5 lbs.	25 lbs.	40 lbs.	Over 40 lbs. Cents per lb.
149	$1.00	$1.00	$1.00	$1.32	3.07
349	1.02	1.10	2.30	3.68	9.21
549	1.07	1.42	3.84	6.14	15.35
1049	1.17	1.98	7.68	12.28	30.70
2349	1.43	3.53	17.65	28.24	70.61
Over 2350	1.47	3.68	18.42	29.47	73.68

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rays generated by the new lamp activate the multi-colored fluorescent pigments on the dials and knobs. Tubular lamp itself is a simplified miniature version of ordinary fluorescent tube; but in place of the phosphors selected for the production of visible fluorescent light, special u-v. phosphors coat inner surface of lamp; and special glass mask blocks out stray visible light (present even with black-light phosphors) while permitting invisible u-v. light to be transmitted. Under average usage, new lamp should burn five years without replacement. Its life is unaffected by frequent turning on and off. Lamp is a trifle longer than a fountain pen and its luminous length is 7″. It is of the non-blinking, instant-start type. Assembled from three parts—two end caps and a glass tube—new u-v. lamp is the "most elementary fluorescent tube ever developed," it is said. "The end caps function in a double role as bases and electrodes, acting as connecting links for the stream of electrons flowing through the tube."—*Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.*

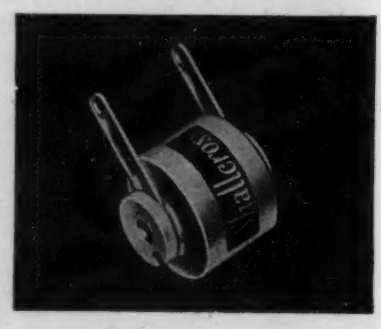
Short-range pH Test Papers and Dispensers

Six new "Hydrion" short-range pH test papers are announced. Color changes for small pH intervals are said

to be so well defined with these papers that readings can be made to 0.25 pH. The six papers cover the range pH 1 to 14. Transparent plastic dispenser holds two papers in roll form. These new short range papers supplement the original "Hydrion" wide range papers and are said to be a useful supplement to any other method of determining pH. —*R. P. Cargille, 118 Liberty St., New York 6, N. Y.*

Half-watt Resistor

New "Type 1101" hermetically-sealed wire-wound resistor rated at 0.5 watt and only ⅞″ long × ⅞″ in diameter is



designed for style RB12A under JAN Specification R93. Maximum resistance value when wound with nickel chromium wire is 350,000 ohms, maximum voltage 420 volts. Resistance element, winding form and protective ceramic shell form a rigid, integral unit. No internal leads or "floating" wires are used. Hermetic-sealing is obtained without use of ferrule caps or glass drawing by a special solder process.—*Shallcross Mfg. Co., Jackson and Pusey Avenues, Collingdale, Pa.*

Air Regulator-Filter-Lubricator

New "R-F-L Unit" incorporates all components of "Christmas tree" assembly of reducing valve, pressure gage, filter and lubricating device, in a cast-

Fig. 1

ing measuring 6" square by 4¾" deep. All connections are built into the casting and are controlled from or visible on the front panel. Unit is mounted in the air intake line from the main air line, and is adapted to location on a central control panel. It is equally effective when used with old or new equipment; it can be incorporated in air devices on the market. In operation, new unit levels out surges and sudden drops in air supply, and keeps working pressure uniform with minimum air consumption. Filter and lubricator assist any air equipment to operate at peak capacity, and effect a marked increase in service life. Two knobs accurately adjust air pressure and amount of oil injected; third knob drains water trap when necessary. Recessed plug is quickly removed for convenient refilling of oil revervoir. Inlet and outlet ports, drain ports and mounting holes are provided in alter-

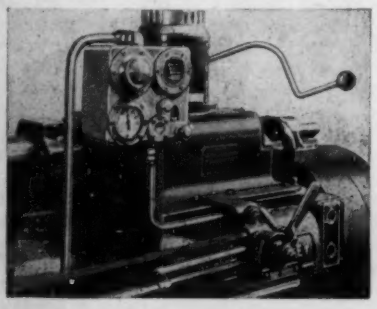
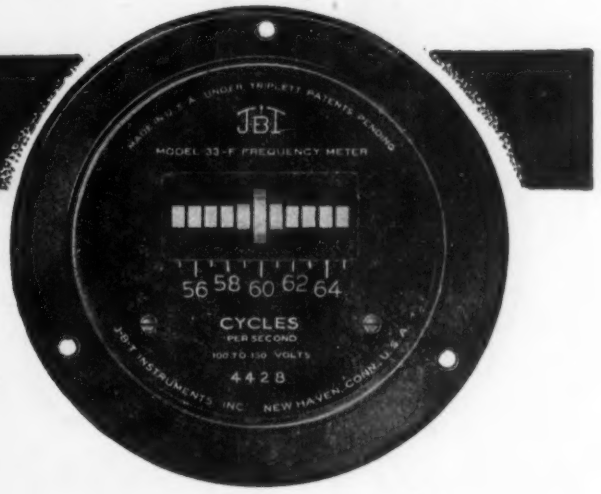


Fig. 2

How to Get Your Money's Worth

in FREQUENCY METERS



Model 33-F, Full-cycle increment, shown indicating frequency of 60 cycles. Black dial for special application.

Check These Points

Here are the facts on

J-B-T VIBRATING REED FREQUENCY METERS

ACCURACY

Half-cycle increment, ±0.2%; full-cycle increment, ±0.3%. This accuracy is not affected by normal *temperature* change, *wave form* or *external magnetic* fields.

COMPACTNESS

Made in several sizes, most popular of which is the standard 3¼" panel mounting model. Also made to meet C39.2-1944 ASA specifications and Jan-I-6 for mounting and stud size of Electrical Indicating Instruments. No external reactor.

WEIGHT

Model 31-F, 3½ inch, 5 reeds, weighs only 0.54 lb; Model 33-F, 3½ inch, 11 reeds, 0.59 lb. Other models are correspondingly *light*.

VOLTAGE VARIATION

Will operate on voltages as low as 8 volts. Standard 110-115 volt models will operate satisfactorily over range of 100 to 130 volts. Also made for narrower voltage variation if desired. (Incidentally, current consumption is low. For Model 33-F, for example, ½ watt at 115V.)

RUGGEDNESS

No parts to wear out or get out of calibration. All are securely anchored to the base with lock washers at every critical point. The only movement is at the free end of the spring steel reed. J-B-T meters on portable field equipment have established an enviable performance record.

J-B-T Vibrating Reed Frequency Meters are available for frequencies from 12 cycles to 525 cycles with various reed groupings, increments and case sizes. For additional facts on the complete line, send for Bulletins VF-43, VF-43-1A (400 cycle Meters) VF-43-1B (2½" sizes), and VF-43-1C (interesting new applications).

J-B-T

(Manufactured under Triplett Patents and/or Patents Pending)

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SMALL...but what CAPACITY

Hathaway Type S-12 Oscillograph combines small size and portability without sacrificing accuracy, capacity and recording quality. Capacity up to 12 channels, permanent film or paper record, interchangeable high frequency galvanometers and many automatic features. Viewing screen permits simultaneous viewing and recording.

Hathaway Type S-12 Oscillograph is indespensable where portability, accuracy and ease of control are fundamental—*it's as easy to take with you as a brief case.*

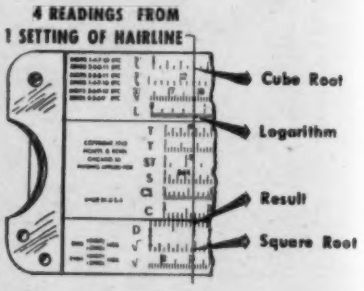
☆ Delivery 60 to 90 days. Write for bulletin SP-167. Hathaway Instrument Co., 1315 S. Clarkson Street, Denver 10, Colorado.

Hathaway INSTRUMENTS

nate locations. In regulator, control of bellows-type reducing valve has long travel, permitting accurate adjustment to required air pressure. Replaceable porous metal filter traps moisture and foreign matter, supplying only clean, dry air to the air system. Filter is easily removed for cleaning. Water reservoir requires draining only once or twice a week. "O" ring construction of drain valve assures leak-proof operation. Lubricator automatically meters required amount of oil into air supply. Sight glass in front panel shows oil level in the reservoir. "R-F-L Unit" is designed for working pressures to 150 lbs./in.^{2}. Illustrations show (1) "R-F-L Unit" installed in air intake line of a Warner & Swasey turret lathe; (2) unit mounted on a central control panel.—*Logansport Machine Co., Inc., Logansport, Indiana.*

Dowmetal Slide Rule

New model of "Deci.Point" slide rule originally announced in *Instruments*, Feb. 1945, page 124, is being manu-



factured of light-weight Dowmetal which is said to make possible a number of advantages. Accuracy is superior to accuracy of previous model because Dowmetal is not affected by climatic conditions of heat, cold or moisture. There is no perceptible warping, swelling or other distortion. Dowmetal can be machined to extremely close tolerances, permitting self-centering "optical groove" construction which prevents side play and binding. Dowmetal core is surfaced with a flat white plastic impervious to water or chemicals and said to be virtually immune to abrasion from regular use. Rule is 12⅛" long and 2" wide, comes with manual, typical problems and carrying case.—*Pickett & Eckel, 53 W. Jackson Blvd., Chicago 4, Illinois.*

Direct-reading Fluxmeter

New "MFM2" and "MFM3" Direct-reading Magnetic Fluxmeter for laboratory, school and maintenance uses, was originally developed for the Armed Services (by maker's engineers in cooperation with OSRD at the MIT Radiation Laboratories) for high-precision measurement of field strengths of magnets used with magnetron assemblies, but now finds numerous industrial and school uses. It can be used to measure magnetic fields and gaps ½" or greater, within the range of 1200 to 9600 gauss. The fluxmeter consists of two permanent-magnet moving-coil instruments connected in series provided with suitable shunts, current and range selection controls. Both these instruments are

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Indicating R.P.M., F.P.M., etc.
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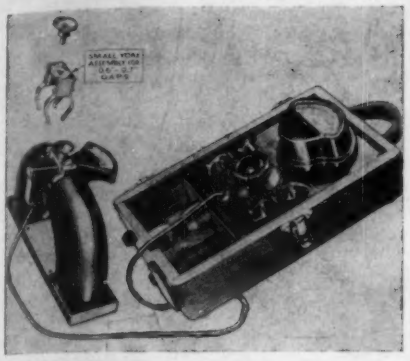


Fig. 1

unusual: Probe element or search-coil assembly is a special moving system of extremely small size, whose components have all been minutely inspected and graded for magnetic impurities in fields up to 25,000 gauss. Probe meter derives its energy from the magnet under test. A current, passed through its moving coil assembly to deflect it to a fixed point on its scale, is then measured in terms of gauss, on a special suppressed-scale milliammeter. It is said that by use of calibrating devices of extreme accuracy, 0.1% components and matched temperature coefficients of the circuits, over-all accuracy of the instrument in all fields and at all points on the scale is considerably better than 1%. Gauss meter is steel-encased to provide shielding from the very strong magnetic fields which it may encounter, has a suppressed scale that permits the use of a 4" instrument equivalent in scale spread and accuracy to an 8" or 9" indicator. This instrument reaches zero point on left-hand side of scale when one milliam-

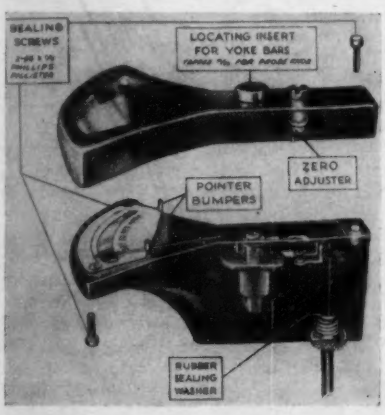


Fig. 2

pere of current is flowing, and reaches full-scale when 2 milliamperes of current are flowing through the circuit. Ordinarily, it is impossible to properly zero-set an instrument of this nature, but new direct-reading fluxmeter has a current-dividing network which permits zero-setting to be made in normal manner at zero point on indicator without affecting suppression feature. Fluxmeter is extremely rugged: it was used in the field with all types of combat radar equipment; it does not require leveling or special search coils. It indicates field strength directly in gauss and may be used also to monitor magnetic field strengths continuously. *Principal data:* Weight 6½ lbs. Carrying case of hand-rubbed oak, 5" × 6" × 10½". Power

If you want a Vacuum Tube Voltmeter you don't have to coddle—one that gives accurate readings in spite of routine knocking about—

THE JACKSON Model 645 AC-DC ELECTRONIC VOLT-OHM-MILLIAMMETER

is the instrument for you. Here are the condensed specifications.

Both A.C. and D.C. volt ranges are Electronic. This provides maximum sensitivity and overload protection for all A.C., D.C., and ohms ranges.

Measures resistance up to 1 billion ohms (1 thousand megohms)—and as low as 2/10 ohm.

3 million ohms per volt sensitivity on 0-4 volt D.C. range. Constant input resistance 12 megohms on all D.C. volts ranges.

Over 4 million ohms per volt sensitivity on 0-1 volt A.C. range. Input resistance of 4.4 megohms on all A.C. ranges. Flat frequency response between 50 cycles and 200 kilocycles.

Meter cannot be damaged by accidental overload on any electronic range. Electronic overload protection on all A.C. and D.C. volts, and ohms ranges. Variations in line voltage do not affect accuracy within the range of 100 to 125 volts. Equipped with ballast control tube and self-compensating circuits.

Contains 3 tubes (6X5GT/6K6GT/7N7), neon regulator, 1-4½ volt battery and ballast; self-contained, furnished with the instrument.

Meter ranges—

A.C. Volts: 0-1/4/10/40/100/400/1000
D.C. Volts: 0-4/10/40/100/400/1000
Ohms: 0-1000/10,000/100,000/1meg/10meg/100meg/1000meg
M.A.: 0-1/4/10/40/100/400/1000
Decibels: Minus 30 to minus 5/minus 10 to plus 15/10 to 35/30 to 55

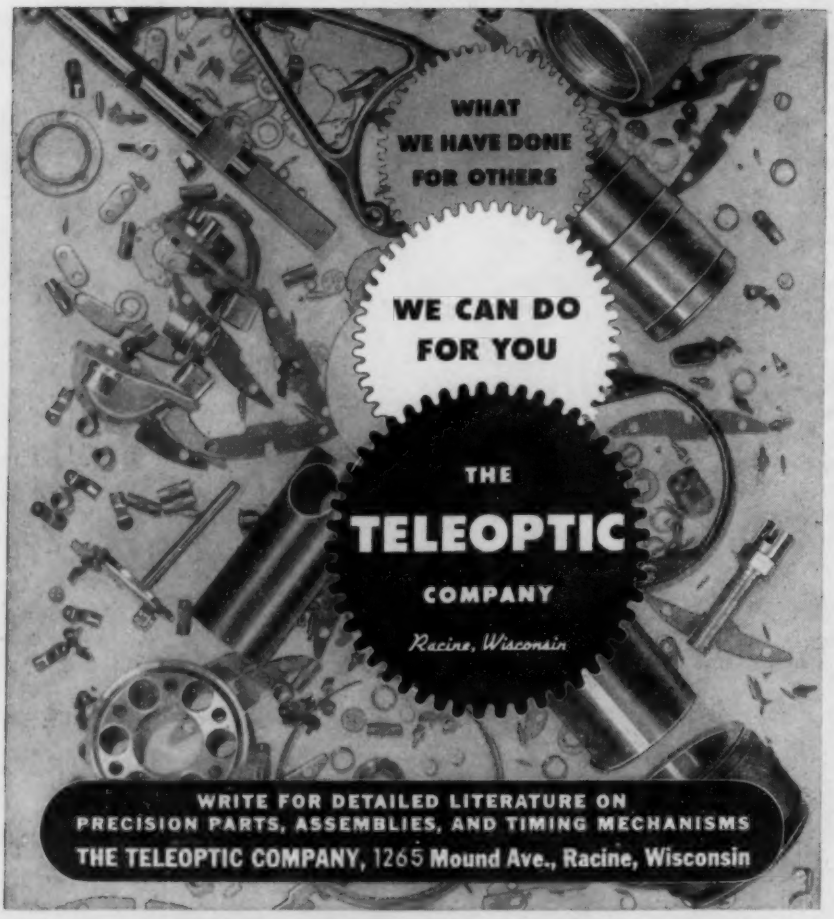
Either positive or negative D.C. voltmeter indications instantly by means of reversal switch. Signal Tracing type test lead, isolation resistor in probe.

Dimensions—8½" x 8½" x 6"—Unit welded steel case, grey morocco finish.

JACKSON

Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO



source, a single Type D flashlight cell. Cable on the probe element is 4½ feet in length. Unit is provided with adapters for use with magnetron magnet assemblies having gaps of 0.550" to 0.750", with pole diameters of ¾" and with adapters for gaps of 1.3" to 1.5" with pole faces of 1⅝" and 2" diam. For magnetic measurements in fields of non-standard magnets, and other sources, probe element is marked with centering lines and provided with a handle. In use, all that is required is to insert probe into rough geometric center of field to be measured, turn current control until probe pointer deflects to red mark at full-scale and then read field strength on scale of gauss meter. Probe can be removed from field and instrument read at any time, since it is of constant-indicating, not ballistic type. — *Marion Electrical Instrument Co., Manchester, N. H.*

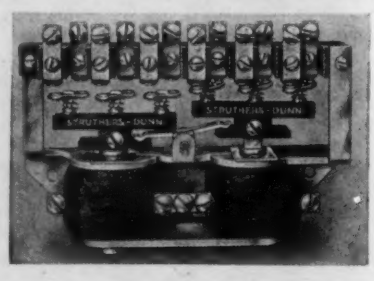
Precision Resistors

New "Series 84" resistors are precision-grade units designed to be mounted by means of a through-bolt

and equipped with a radial lug at each end. "Riteohm 84" is pie-wound to 1% accuracy and is available in 3 sizes: 9/16" diam. × 9/16" long, 9/16 × ⅜", and ¾" × 1 3/16". Smallest is a 2-pie while the other two are 4-pie units. Minimum resistance is 1.0 ohm for 2-pie unit and small 4-pie unit, and 0.10 ohm for large 4-pie unit. Maximum resistance is 200,000 ohms for 2-pie, 400,000 ohms for small 4-pie, and 1.5 megohms for large 4-pie unit. Among uses: voltmeter multipliers, laboratory equipment, radio and electrical test sets, attenuation pads and in electronic equipment requiring accurate resistance components. Enameled alloy resistance wire is non-inductively pie-wound on non-hygroscopic ceramic bobbin with hole through center for No. 6 screw. Lug type terminals are firmly fastened to bobbin. After being wound, unit is vacuum impregnated with special varnish which provides additional insulation and protection against humidity. —*Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.*

Reversing Contactor

New "Type 135CXX" heavy-duty reversing contactor is 5¾" wide × 4" high × 1⅞" deep, weighs approx. 2½



IMPORTED SWISS
5-RANGE, CENTRIFUGAL TYPE
HAND TACHOMETERS

CATLG. NO. 303	CATLG. NO. 346
30—120 RPM	120—480 RPM
100—400 RPM	400—1600 RPM
300—1200 RPM	1200—4800 RPM
1000—4000 RPM	4000—16,000 RPM
3000—12,000 RPM	12,000—48,000 RPM

FOR DETAILS WRITE FOR BULLETIN NO. 750. NO PRIORITY REQUIRED

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77 PARK PLACE NEW YORK N.Y.

REX RHEOSTAT COMPANY, BALDWIN, L. I., N. Y.

PROTECTED and UNPROTECTED
TUBULAR SLIDE-CONTACT RHEOSTATS
WITH SELF-LUBRICATING CONTACT BRUSHES
ADJUSTABLE RESISTORS

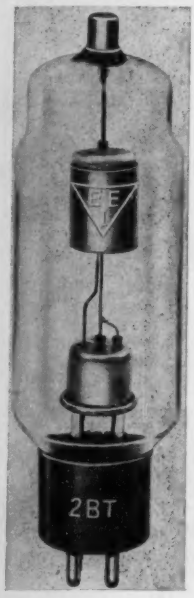
PROMPT SHIPMENTS

REX RHEOSTAT CO.
BALDWIN, L. I., N. Y.

lbs.; is designed for use with polyphase motors up to 1 h.p. and single-phase motors to ¾ h.p.; and is available from 110 volts to 600 volts a.c. It consists of two 3-pole contactors mechanically interlocked. Thus it is suited for control operation on small hoists, machine tool cross feeds and a wide variety of other applications. Smaller size, lighter weight and consequent lower cost are accomplished by use of a simplified one-piece solid frame structure. All contacts, terminals and coil leads are accessible from front without removal of any parts. All fixed contacts are interchangeable to permit easy replacement from a minimum stock, as are the moving contacts. — *Struthers Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.*

High-vacuum Rectifier

New "EE 2BT" is a high-vacuum tube with peak inverse voltage rating of 40 kv.; average anode current 5 milliamps. It is said to close gap in available types of rectifiers for television applications. It has high peak inverse rating and is expressly designed for plate supply in video receivers requiring potentials to 12,700 volts on the projector tube. By incorporating the "EE 2BT" it is claimed that engineers can eliminate flashback trouble without specifying a rectifier with ratings in excess of actual requirements.—*Electronic Enterprises, Inc., 67 Seventh Ave., Newark 4, N. J.*



Heat-screen Glass

New heat-absorbing, color-transmitting glass makes possible improved projection of color pictures and cooler working conditions for motion picture and television actors. Also, when used as a heat screen in a projector, it permits the projection of motion and still pictures in their original colors; and since it absorbs heat emitted by the light source, films and slides are protected against damage or burning. This insulating property enables film editors and educators to study a specific projected scene by stopping the projector and relying on the glass to protect the film. New glass absorbs approximately 90% of infrared (heat) radiations and transmits approximately 85% of light out of a possible 92% (8% being lost by reflections). If reflections are reduced by glare-removing methods, light transmission can be increased from 85 to 90%. New glass transmits colors accurately, is chemically stable, resists weathering without requiring a surfacing treatment, and can be molded, ground and polished, and fabricated like ordinary glass. It is formed from

REGULATED POWER SUPPLY
250-450 VOLTS
Wide fields of application have been opened up both in research and industry for this unit. A-C ripple is negligible and extreme care has been taken to eliminate high-frequency noise. Regulated power supply units are invaluable for such applications as amplifiers, television pulse generators, constant frequency oscillators, and measuring equipment.
Other G-E regulated power-supplies are available in the following ranges: 180-300 volts 160-1500 volts Dual Regulated
Write today: Electronics Department, Specialty Division, General Electric, Syracuse, N. Y.
Electronic Measuring Instruments
GENERAL ELECTRIC
PS-1

Front or Rear Surface
MIRRORS AND REFLECTORS
FOR TELEVISION, ELECTRONIC, OPTICAL, and SCIENTIFIC APPARATUS
Front or Rear Surface Mirrors and Reflectors made to your specifications.
Closest optical and dimensional tolerances observed.
EXCEPTIONAL REFLECTIVITY
WILL NOT TARNISH
OPAQUE OR SEMI-TRANSPARENT
HEAT RESISTANT
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We invite your inquiries. Samples and quotations will be submitted promptly.
Let Zenith help solve your Mirror and Reflector problems!
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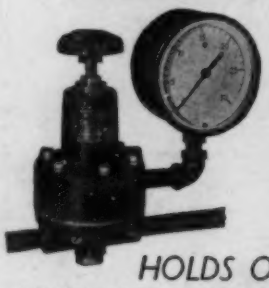
THE NULLMATIC
PRESSURE REGULATOR



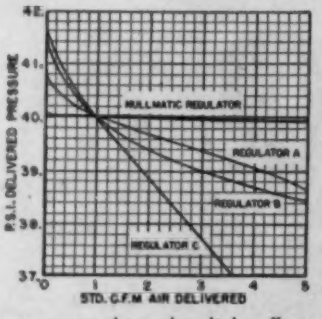
HOLDS OUTPUT PRESSURE CONSTANT
regardless of wide changes in flow or in supply pressure

This instrument is actually a pressure controller in which the main valve is operated by a pilot nozzle. Recommended for precision regulation of air and gas pressures, in dead-end service, and with flows up to a maximum of 45 s.c.f.m.

PERFORMANCE

The NULLMATIC Regulator provides accurate and dependable manual control of air-operated valves, dampers, and air-loaded cylinders. The automatic bleed feature permits lowering the control pressure when required. A separate safety release provides positive protection against overload.

EFFECT OF CHANGES IN FLOW



These curves show the slight effect of flow changes on the NULLMATIC Regulator, compared to the performance of several non-piloted instrument-type regulators. In the tests, each regulator was set to deliver 40 p.s.i. at 1 s.c.f.m. flow (with 60 p.s.i. supply), and this setting was maintained while the flow was varied. At 5 s.c.f.m., the NULLMATIC Regulator varied less than 1" H_2O delivered pressure.

NULLMATIC
PNEUMATIC NULL BALANCE INSTRUMENTS
for measurement & transmission of
PRESSURE
TEMPERATURE
SP. GR. FLOW
LIQUID-LEVEL

Bulletin 402 shows standard ranges and performance

MOORE PRODUCTS CO.
912 E. LYCOMING STREET
PHILADELPHIA 24, PA.

carefully-balanced proportions of phosphorus, aluminum and silicon oxides; supplemented by various conditioning ingredients together with ferrous iron as the heat-absorbing agent—*American Optical Co., Southbridge, Mass.*

Midget Vibrator

New "Midget Vibrator, VR-2," said to be the smallest vibrator made, measures 2⅛" high by 1⅛" diam., was a special war development designed for operation from a small 6-volt storage battery in furnishing power to replace dry battery power in certain communications equipment; has numerous civilian applications. Specifications are as follows: Vibrator frequency, 185 cps. ±10%; Nominal input voltage, 6.0 v.; Input voltage range, 4.5 v. to 7.5 v.; Input current, 1.5 amps max. at 6.0 v.; Output voltage, 200 v. d.c. max.; Potential difference between primary reed and secondary reed, 25 v. max. Illustration shows vibrator in full size.—*The Radiart Corporation, 3571 W. 62nd St., Cleveland 2, Ohio.*

Molding Sand Pressure Tester

New "Portable Gas Pressure Determinator" has been developed for rapid determination of the gas pressure created by molding sand or cores. It uses a 1⅛" × 3" sand or core specimen which is attached to its stem. This specimen is then immersed in molten metal. Pressure of gas envelope created by specimen is shown on gage at other end of stem. New Gas Determinator thus makes it possible to measure pressure of mold-metal interface gas envelope by a practical method that

Rawson
Twin Multimeter

29 Ranges in Less Space Than Any Near-Equivalent Combination
Size 12" x 8" x 6"

RANGE OF MEASUREMENTS

D.C. 1 microampere to 1 ampere
20 microvolts to 1000 volts

A.C. (up to 3000 cycles)
2 milliamperes to 3 amperes
60 millivolts to 1000 volts

Special Apparatus Built to Order

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New York, N. Y. Chicago, Ill.

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 36 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

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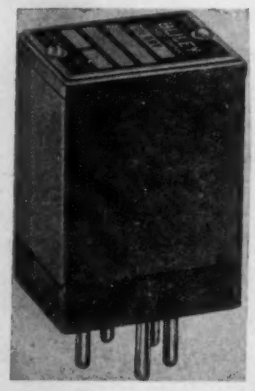
Illustrated bulletins free.

The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Ave., Jamaica, N. Y.

simulates mold conditions. Sand or core mixture to be tested is rammed to the chosen hardness by means of maker's "No. 754 Sand Rammer." A special pedestal furnished with Determinator contains a hole to receive a specimen tube ¼" O.D. × 7⅛" in length. End of tube projects 2⅞" above special pedestal so that open end of tube is ⅛" from top end of the rammed specimen. (See illustration.) Rammed specimen with tube may be then dried or baked, or attached to the Determinator in the green state. Tube with specimen on one end is then inserted into lower end of Determinator. A heat-resisting gasket makes a gas-tight joint. Tightness of this joint is adjusted by turning handle of Determinator. Specimen on end of tube is then immersed 2½" into a ladle of molten metal. Gas pressure is read in inches of water pressure. This new method, wherein specimen is immersed in the type of metal to be cast, is said to solve many perplexing problems. Heat conductivity of metal-mold interface is automatically taken into consideration. Net weight of unit is 5 lbs. and shipping weight is approx. 15 lbs.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit 4, Mich.*

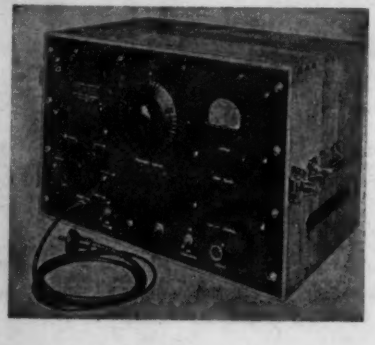
VHF Crystal Unit

New "Type ART" crystal unit for VHF services is a ruggedly-built temperature-controlled assembly designed for services where frequency stability must be maintained throughout temperature range from -55°C. to 75°C. A built-in heater operating on 6.3 volts at 1 ampere provides temperature control within ± 2°C. This permits an over-all frequency tolerance of ± 0.005% or better including variations due to temperature change as well as tolerances required for crystal production. "Type ART" crystal unit is available for any frequency between 3500 kc and 11,000 kc.—*Bliley Electric Co., Erie, Penna.*



R-f. Signal Generator

New high-level radiofrequency signal generator covers the range from 400 kc to 60 Mc in six steps. Modulation of



HIGH-VOLTAGE TEST SETS

This new bulletin presents a full line of highly accurate, portable "time savers" for making practically *any* A-C high-potential test. Twenty-four pages of comparative specifications, photographs and data are given on ten standard portable test sets, including portable oil and insulation testers and general purpose test sets, with ranges from 2000 to 150,000 volts, 0.25 to 25 kva. Information is also given on sphere gaps and other specialized G-E testing equipment. *If you use electric equipment, heavy or light, you need this bulletin!* Write today for Bulletin GEA-4477, *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Make G-E Your Testing Equipment Headquarters

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Protection to life and property are assured by frequent and accurate testing of resistance to earth, of man-made grounds. VIBROGROUND has long demonstrated its exceptional dependability. Not affected by prods, lead, nor frequency. AC or DC currents in ground do not distract from accuracy. No calculations required. Light. Portable. Easy one-man operation. Self-contained power source. NO CRANKING.

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.00001" is less than 1/30 the diameter of the smallest wire die commercially available. Yet our Wollaston Process wire (drawn in a silver jacket) closely meets your specifications for diameter, resistance and other characteristics.

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30% at 1000 cps. is optional by means of a panel switch. Output is 3 volts (RMS) at all frequencies and is read directly from a panel voltmeter. Output is through an output jack and coaxial cable terminated in a 75-ohm resistive load. Calibration is accurate to better than ½ of 1% and is read from a large individually calibrated chart mounted on lid of each cabinet.—*Barker & Williamson, 235 Fairfield Avenue, Upper Darby, Penna.*

Close-tolerance Resistors

Four new types of resistors, said to combine close tolerance, high quality and low unit cost, are available for

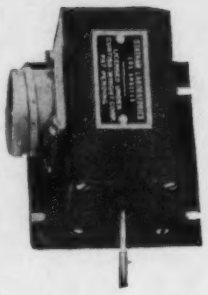
immediate delivery in quantity. "Type ALA": 3 watts; max. resistance 25,000 ohms (Nichrome) or 5000 ohms (Manganin); size 1⅝" × ⅜"; axial lead mounting, No. 18 tinned copper terminal leads 2" long; standard tolerance 3% (1% at extra cost). "Type ACA": 6 watts, same as "ALA" except coated with high-temperature cement. "Type BLA": 5 watts; max. resistance 50,000 ohms (Nichrome) or 10,000 ohms (Manganin); size 1⅝" × ⅜"; mountings and tolerances same as "ALA." "Type BCA": 10 watts, same as "BLA" except coated with high-temperature cement. All four new types can be supplied with non-inductive winding with 50% reduction in max. res. — *Instrument Resistors Co., 25 Amity St., Little Falls, N. J.*

Four-way Control Valves

New "Modernair Model CV" 4-way control valves, designed for the control of air and low-pressure hydraulic systems, are adapted to hand, foot or pilot

Fig. 1

The STATHAM GAGE



Displacements as minute as 0.000008" or **Force Changes** as small as 0.02 oz. are readily detected by the Statham Gage without expensive electronic equipment. Complete system for remote indication or recording comprises Statham Gage, dry cells, and microammeter or recording galvanometer.

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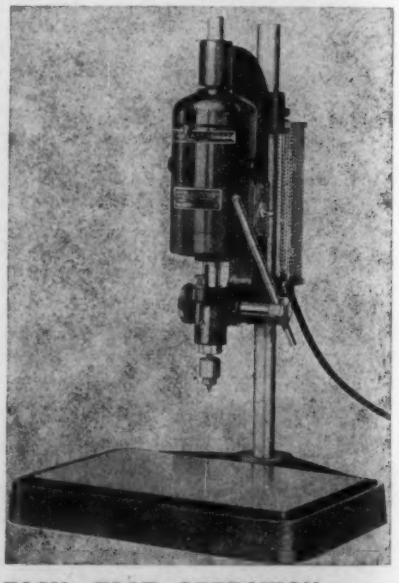
HIGH SPEED PRECISION DRILL PRESS



EASY, FAST OPERATION . . . REDUCTION of DRILL BREAKAGE

Vibration-free variable speed, governor controlled, ball bearing motor (AC-DC) maintains max. spindle torque from 1000 to 15000 RPM. Selective fine or coarse quill drive assures sensitive, easy and fast drilling from .004" to 5/32" with over 200% increased drill life. Max. chuck run-out .0001". 8 models adaptable to single or multiple head set-ups.

COMBINES ACCURACY with ECONOMIC PRODUCTION

THE ELECTRO-MECHANO CO.

261 E. Erie St., Milwaukee 2, Wis.

operation by simple assembly changes of identical housings. New valves are fully balanced, use aircraft type packing and are free of metal-to-metal contact between wearing parts. Design permits transmission of full line volume and pressure through valve without operation of valve being affected by variation of line pressure; also permits use normally "on" or "off" in three positions, with center position being "neutral." In "neutral" position, when valve is used for cylinder control, unit may be arranged to permit positioning of piston with pressure balanced on both sides of piston, or with pressure relieved at both piston ends. All of the adaptations as hand, foot or pilot-operated valves can be used as single 3-way valve by plugging one outlet port or as two 3-way valves in series. When unit is installed as two 3-way valves in series, one valve will have the pressure

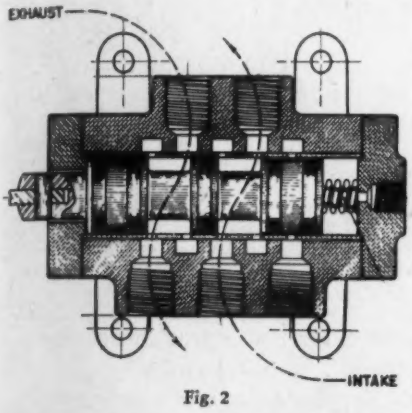
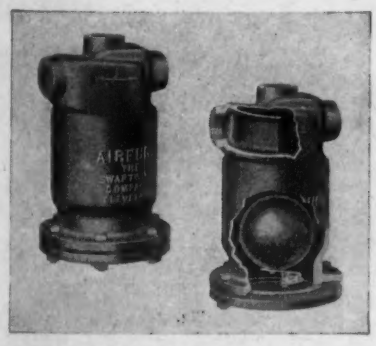


Fig. 2

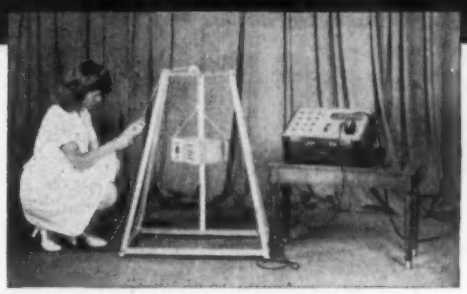
on, while the other will have the pressure off. Using the same assembly of housing, piston rod and end plates, a hand- or foot-operated "CV" valve converts to pilot operation by removal of one end plate and replacement of the piston and end plate. These changes may be made without breaking line connections. New valve is normally furnished with ⅜-18 NPT Female ports at 1" spacing on centers; is also available in ¾"—18 port size (other sizes in near future). Mounting pads are 4⅜" over-all with 9/32" diameter holes on 2-13/16" centers. Width of valve body (port facing to port facing) is 3⅛". Over-all width of valve body is 2-7/16". —*Modern Products Limited, 952 South Grand Ave., Los Angeles 15, Calif.*

Air Separator

New "Airfuge" is a separator for removing moisture, oil, scale, etc., from compressed air. It utilizes centrifugal principle, whereby delivered air is 99%



IS YOUR PRODUCT PROTECTED FROM
"SHIPPING SHOCK?"



BE SURE... CHECK YOUR PACKING SYSTEMS WITH THE G-E CUSHIONING METER

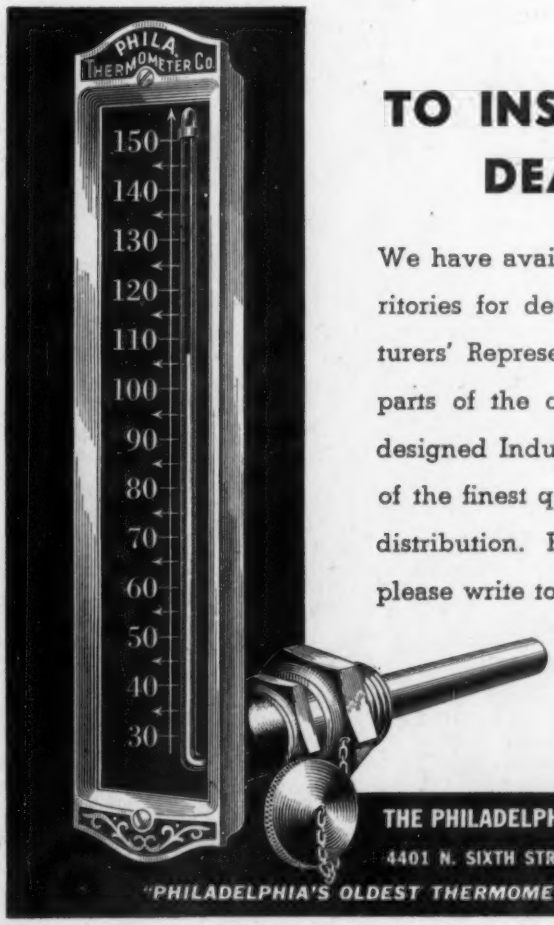
ECONOMICAL—without damaging expensive equipment, it provides a simple means of determining the protection against shock afforded by your packing systems.

EASY TO OPERATE—requires no adjustment during measurement. A scientific means of determining whether your product is safeguarded against "shipping shock."

SELF-CONTAINED—in one easily portable case. Operates from any a-c 110-volt, 50/60-cycle outlet.

Also useful for determining the shocks to which equipment is subjected in service. Write for Leaflet GEA-4472. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC



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"PHILADELPHIA'S OLDEST THERMOMETER MANUFACTURER"

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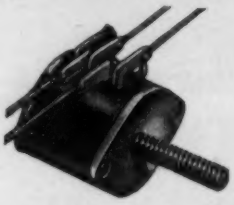
COPPER OXIDE RECTIFIERS



Coprox Model CX-4D4F23.

A full-wave rectifier with high conversion efficiency, for electronic control work. Rated at 6 volts A.C., 50 milliamperes D.C. continuous. Fully enclosed. Mounts on a single screw.

All Bradley rectifiers have special features that give long life, make for easy assembly and assure accurate performance. Bradley's application experience can be called upon for the development and production of special rectifiers for special jobs.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

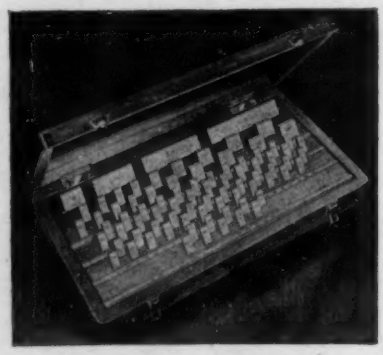
BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

or more free of contamination. Cleaned air may be taken off horizontally or vertically from pipe-tapped ports. An integral float-operated trap releases condensate automatically. Separator is made of high-tensile iron; interior parts of corrosion-resisting materials. Bottom easily removed if necessary for cleaning. Made in three sizes for varying capacities and with a range of pipe connection sizes.—*The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.*

82-piece Gage Block Set in Carbide

New "No. 82-C Tungsten-Carbide Set" is comparable in quality in every respect to the 35-piece tungsten-carbide set recently introduced by maker (see



Instruments, Oct. 1945, page 743). In new set, block sizes range from 0.050" to 4". Set includes 9 pieces in 0.0001" steps from 0.1001" to 0.1009"; 49 pieces in 0.001" steps from 0.101" to 0.149"; 19 pieces in 0.050" steps from 0.050" to 0.950"; 4 blocks of 1", 2", 3" and 4" respectively; and 1 piece of 0.10005". Grades "AA" ±0.000002", "A"±0.000-004" and "B" ±0.000008". This 82-piece set provides more than 480,000 combinations in wringing.—*Fonda Gage Co., 59 Daly St., Stamford, Conn.*

Volt-ohm-milliammeter

New "Model 2405" volt-ohm-milliammeter with d-c. volt ranges at 25,000 ohms per volt provides for voltage,

current and resistance analyses. Ranges are: D-c. volts: 0-10-50-250-500-1000, at 25,000 ohms per volt; A-c. volts: 0-10-50-250-500-1000, at 1,000 ohms per volt; D-c. amperes: 0-10; A-c. amperes: 0-0.5-1-5-10; D-c. milliamperes: 0-1-10-50-250; D-c. microamperes: 0-50; Ohmmegohms: 0-4000-40,000 ohms-4-40 megohms; output: capacitor in series with a-c. volts. Six-inch "Model 626" Microammeter, adjusted to 40 microamperes, carries "Red • Dot Lifetime Guarantee" against defective workmanship or materials. New "Square Line" metal case, 10" × 10" × 5¾", complete with detachable, hinged cover and compartment for instructions and accessories, is finished in tan "hammered" enamel. Leather strap handle for portable use. Batteries self-contained. Leads furnished. Weight approx. 11 lbs.—*The Triplett Electrical Instrument Co., Bluffton, Ohio.*

Greases for High-speed Instrument-motor Ball-bearings

New Silicone greases, "DC 33" and "DC 44," are serviceable in ball bearings operating at speeds up to 10,000 r.p.m. and are subject to bleeding of less than 2% after 16 hours at 110°C. (203°F.) "DC 33" is effective over a temperature range of —94°F. to 300°F.; "DC 44" is serviceable at temperatures ranging from —4°F. to 345°F. Their low volatility and their very slight tendency to bleed recommend them for the sealed-in lubrication of ball bearings and for the lubrication of bearings operating at abnormally high and low temperatures.—*Dow Corning Corp., P. O. Box 592, Midland, Mich.*

Stencils for Three-dimensional Drawings

New "Instrumaster" line of stencil type drafting instruments comprises one (Fig. 1) intended for isometric drawings, the other (Fig. 2) for Di-

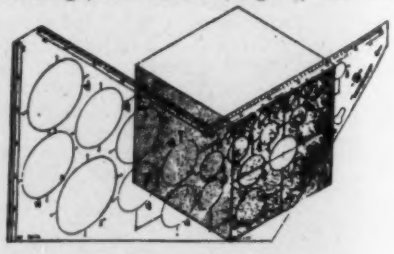


Fig. 1

metric drawings. Both are precision cut out of 0.04" clear high grade plastic, graduations and lettering debossed on lower side. They provide inch graduations at full scale (or half scale in the case of one edge in dimetric stencil) along one vertical and two slanted edges. These three edges represent correct directions of isometric and dimetric axes. Each stencil is provided

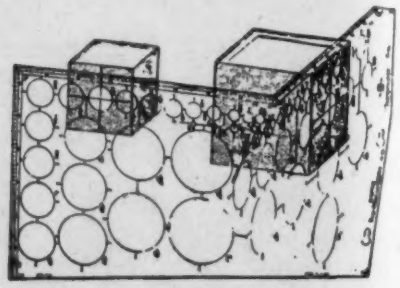
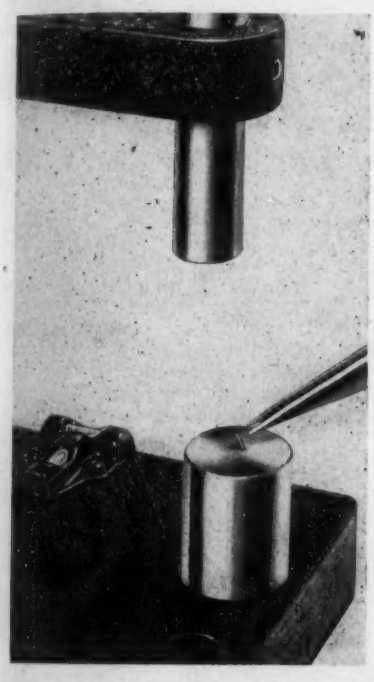


Fig. 2

with 27 ellipse openings correctly representing circles from ⅛" to 2" diameter. Allowance is made for pencil-point or lettering-pen thickness. For correct positioning, center lines are marked clearly by lines and small holes that always line up with the axes through center of ellipse to be drawn. Ellipse sizes are indicated by size of circle to be represented, not by major axis—which also facilitates the draftsman's job. "Professional Size" stencils of the same type with ellipses from 2¼" to 4½" diameter are available also.—*Instrumaster Industries, 76 Arch St., Greenwich, Conn.*

Magnetic Hardness Comparator for Small Ferrous-metal Parts

New Magnetic Hardness Tester for rapid determination of hardness of small ferrous-metal parts is in effect a convenient "go" and "no go" hardness



gage, simplifying inspection of such parts as electric-instrument pivots and shafts, watch shafts and other parts too small to be production-tested with mechanical-type hardness testers. It also permits spot checking of hardness in large sheets, or lengths of steel wire, through the comparison of random-selected small samples. Illustration shows only air gap of new tester, which is 6" long, 3½" wide and 7" high. It consists of an Alnico bar magnet set in an adjustable soft-iron frame, which permits air gap (and thereby field strength) to be set at correct value for testing pieces of different size, whose dimensions are between 1/16" and ½". A knurled thumbscrew locks air gap adjustment, and a brass block for positioning specimens is mounted on base of tester, a little out of the direct line of the magnetic field. A two-way level (seen in photo) is attached to base to show when tester is properly positioned. A pair of brass tweezers is furnished for handling specimens. Operation is based upon correlation of hardness and coercive force in magnetic materials. Instrument checks pieces of unknown

It's "Touch and Go"!

with the CORBIN Hand Tachometer

NO LAG . . . the pointer swings around instantly — follows every change of speed, giving a positive, steady reading at all times. CORBIN cross-balanced centrifugal governor eliminates oscillation . . . mechanism requires no lubrication. Packed in box with rubber pointer, rubber cup and rubber-tired wheel. Choice of ranges and dial markings.

Corbin Screw Division
American Hardware Corp.
New Britain, Connecticut

Accurate CORBIN Tachometers

Laboratory Standards

MODEL 62

VACUUM TUBE VOLTMETER

SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a. c. or d. c.
ACCURACY: 2% of full scale. Useable from 50 cycles to 150 megacycles.
INDICATION: Linear for d. c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a. c.
POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.
DIMENSIONS: 4¾" wide, 6" high, and 8½" deep. WEIGHT: Approximately 6 lbs.
PRICE: $135.00 f.o.b. Boonton, N. J. Immediate Delivery

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UNIFORM HIGH QUALITY
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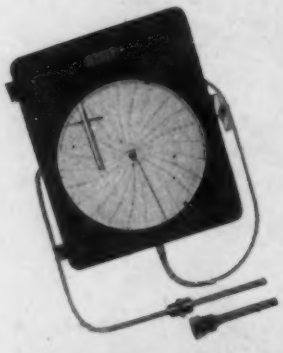

red reading mercury

● At Proctor & Gamble, uniform high standards must be rigidly adhered to . . . and it is not surprising that **Palmer Thermometers** have been selected to help maintain such high standards in their "Crisco".

Palmer Thermometers were selected because of their extreme accuracy and their patented easy-to-read mercury column. Palmer Thermometers are ruggedly constructed, too, for long, dependable service.

To assist your engineers in improving the quality of your products, give them the advantage of reliable Palmer Thermometers. Write for Catalog No. 200 F.

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hardness against a specimen of known hardness by comparing relative strength of magnetism produced in test pieces and in standard specimen, under the same conditions of magnetization. This test will distinguish differences as little as two points on Rockwell "C" scale and does not damage specimens.—*General Electric Co., Schenectady 5, N. Y.*

Demagnetizer

New demagnetizer for small tools with a diameter of 7/16" or less is 3" × 1¾" × ¾" and operates from 115-volt a-c. supply. It is energized by depressing switch button and de-energized by releasing button. To demagnetize a tool, such as a small drill, coil is energized and tool is passed completely through hole of Demagnetizer, and coil is not de-energized until tool is approx. 6" away from Demagnetizer. If a drill end mill or tool bit is not to be removed from its chuck, Demagnetizer is slipped between bed of machine and tool; coil is energized and Demagnetizer is raised

up to the chuck with tool centered in hole. Unit is then slowly lowered with coil still energized until it is approx. 6" away from tool. Unit can also be used to magnetize an object, when such a tool as a magnetized screwdriver is desired. This is accomplished by depressing switch button, placing tool in hole, and releasing button before tool is removed from its position.—*Grayhill, 1 North Pulaski Road, Chicago 24, Illinois.*

1½-watt Hermetically-sealed Resistors

New "Type 1105 Akra-Ohm" hermetically-sealed resistor is rated at 1.5 watts and is designed for Style RB14A

under JAN Specification R93. Thus it fills gap between "Type 1196" at 0.75 watts (Jan RB13) and 2-watt "Type 1110" (Jan RB14). It is 21/16" long × ⅞" diam. and its maximum ratings, wound with nickel chromium wire, are 1 megohm resistance and 1,000 volts. —*Shallcross Mfg. Company, Jackson & Pusey Avenues, Collingdale, Pa.*

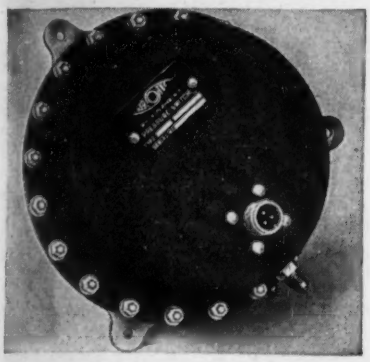
Wear-resistant-alloy Gage Blocks

New "DoALL Lifetime" gage blocks are said to greatly extend the use and application of gage blocks; also to be usable by average person without difficulty. These advantages are made possible by the use of "DoALLoy," a wear-resistant alloy having expansion characteristics similar to steel. Life of new block is sixty times that of steel blocks and twenty times that of chrome-plated blocks. New blocks are said to be "more accurate than the standards set up by the National Bureau of Standards." It is claimed that owing to unique heat treatment and character of alloy, blocks will retain their accuracies even though subjected to temperatures of —120° to 500°. In addition to heat treatments, blocks are sub-

jected to a "DoALL" stability treatment: frozen to sub-zero temperatures and then heated through a series of cycles. All blocks 0.250" or smaller are of solid "DoALLoy," blocks from 0.300" are faced with "DoALLoy" on their wear surfaces. Blocks will not discolor when subjected to many of the acids ordinarily encountered in production. Steel core of faced blocks is chemically treated, leaving a jet black finish which penetrates the surface. This surface is extremely hard, acid-resistant and will not rust. Wringing qualities of new blocks are such that "for the first time the most inexperienced person can easily wring together a stack of gage blocks."—*DoALL Co., 3301 Washington Ave. So., Minneapolis 4, Minn.*

Sensitive Pressure Switch

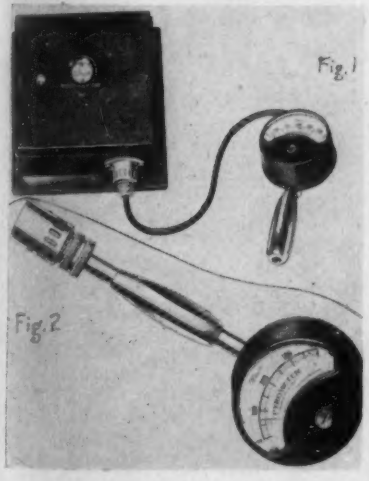
New ultra-sensitive diaphragm pressure switch, originally designed to automatically control the intercooler



flap on fighter planes, is now available for other applications. Specifications show a sensitivity of 0.01" of water on stationary applications. Instrument may be adjusted by means of two knobs to any pressure value desired. For accurately determining these pressures, a draft gage may be connected in parallel with the pressure switch.—*Aerotec Company, White Plains, N. Y.*

Detachable Portable Pyrometer and Switch Box

New combination of detachable portable pyrometer and permanently-installed thermocouples provides dependable temperature measurements under severe operating conditions where a



PRECISION AIR FLOW MEASUREMENTS
With COX Direct Reading Air Flow Meters

THE STANDARD FOR LABORATORY USE SINCE 1925

Why is it preferred over other types of air flow measuring equipment?

It is direct-reading . . . easy to operate
It has continuous operation . . . life-long accuracy
It compensates for pulsating flows
It balances out pressure-drop in line

Where can it be used?

In laboratories of the automotive, aircraft, Diesel, and most other industries where fast and accurate air flow measurements are required.

Major improvements of the new TYPE 7:

Logarithmic Scale for Precision Readings

Multiple Stages in Rectangular Steel Cabinet for closer readings. Wide range of capacities. (up to 2000 cfm)

Specifications

Type 7—Two Stage:
Height ——— 68"
Width ——— 32"
Depth ——— 26"

Available Capacities:
2 to 225 cfm
2 to 375 cfm
2 to 500 cfm
2 to 750 cfm

Fully described in Bulletin 853

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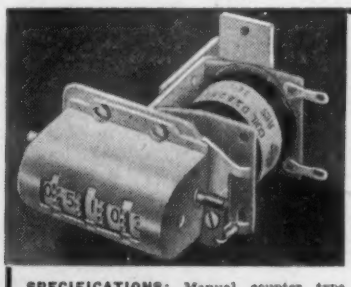
Established 1912

Fig 5951-A
Type 7 Air Flow Meter



40,000 Times
EVERY HOUR!

A G&G HiSpeed ELECTRO-COUNTER, registers up to 40,000 counts an hour . . . it records with consistent accuracy up to 600 times a minute!

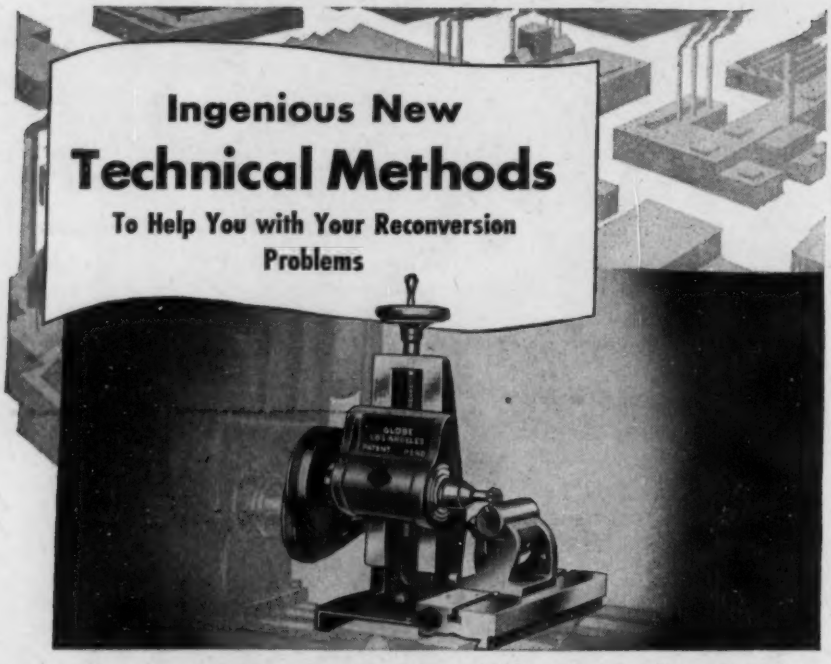
Used for Production Controls, Operational Checks, Functional Actions. Increases accuracy; reduces time or record-taking; permits accumulation of new data.

Compact, sturdy, well-engineered. Mechanism entirely enclosed in cadium-plated housing. Easy-to-read figures behind plastic window.

SPECIFICATIONS: Manual counter type M1. Non-electrical but otherwise exactly as described. Complete with lever. Each: $1.75. Electric counter. Non-reset, type NB1, exactly as shown and described. $4.10 each for 155 volts, 60 cycles. Other voltages from 6 to 220 are 75c extra. Convenient mounting bracket, 26c. Reset electric counter, type R1 (not shown), soon available. 5 digits. Heavy duty. Reset with twist of fingers. Torque motor type, suitable also for electronic circuits. Standard voltages 6 to 220. Net each: $14.50. Write for counter sheet I-246 and facsimile paper sheet "Electrex".

ORIGINATORS and Makers of RECORDING EQUIPMENT since 1925

Correll & Correll
Haworth, New Jersey



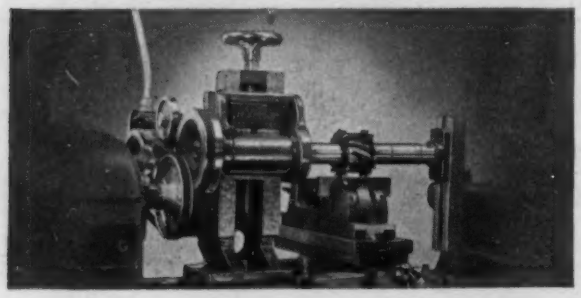
New Unit Makes Milling Machine Out of Lathe in 3 Minutes!

The Globe Miller, a unit quickly attached to a standard lathe, performs the same operations as a costly milling machine. Installed in 3 minutes or less, the Globe Miller operates almost identically to a standard milling machine. All controls are simple, highly accurate—and the miller is designed to utilize all speeds and feeds of the lathe.

It is accurate, durable and highly versatile. With minor adjustments and accessories, the miller will face castings; cut slots, keyways, and gears; perform slitting operations, etc. Quality materials and rugged construction enable it to stand the hardest use. It costs but a fraction as much as a standard miller. Its compact design makes storage possible underneath the lathe. Proved performance in wartime production, assures dependable service.

Performance has also proved that chewing gum helps you on the job—by seeming to make work go easier, time go faster. Today, you'll see good chewing gum on the market. But a shortage still exists. Wrigley's Spearmint Gum is taking this space for your information, and for now, we'd like to suggest that you use any good available brand. Remember: It's the chewing that's good for you.

You can get complete information from Globe Products Mfg. Co., 3380 Robertson Boulevard Los Angeles 34, California

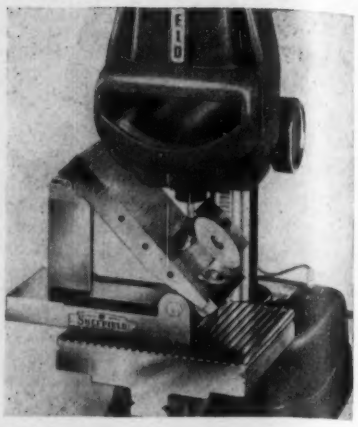


AA-55

permanently-installed instrument would be undependable by reason of excessive vibration, dust and dirt, fumes, etc. New pyrometer equipment is especially adapted to portable engine installations and many uses in industrial plants where conditions are severe. Illustrations show two models of the new portable pyrometer and two forms of installations. Fig. 1 shows maker's "Type T" Multi-point selector switch, permanently wired to thermocouples in heat zones. Switch case has receptacle for attachment of new portable pyrometer for periodic temperature readings. In this form of installation, the model of the new portable pyrometer with flexible cable and attachment plug is held in the hand when readings are taken. Fig. 2 shows the model of the new portable pyrometer with rigid handle and attachment plug. When plugged into the receptacle both hands are free to manipulate the switch and record temperatures.—*Illinois Testing Labs., Inc., 420 North La Salle St., Chicago 10, Illinois.*

Sine Bar Fixture

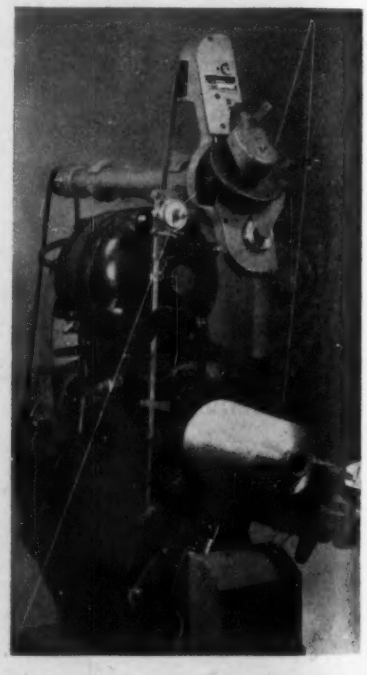
New Sine Bar Fixture is a device for checking tapered and angular work which requires a high degree of dimensional accuracy. It consists of a serrated work surface hinged to a base plate, entire fixture being precision made to a tolerance of 0.0001". Work surface angle is set by using precision



blocks as a reference. Sine Bar Fixture is available in two sizes, 5" and 10", respectively, between hinge center and setting bar center. The 5" fixture may be used on maker's "Visual Gage" equipped with a 6" anvil as shown. Either size fixture is suitable for use on a surface plate with a height gage. An adjustable work stop which may be used on either end of the fixture, and an adjustable backstop usable on either side of the surface plate, are standard equipment. — *The Sheffield Corp., Box 893, Dayton 1, Ohio.*

Yarn Tension and Density Control

New "Tension and Density Control" for the textile industry is especially adapted for winding yarns where tension and package density is important.



It enables operator to draw yarn from any over-end supply and at decreased speeds from a revolving supply. Upper assembly is essentially a device to feed yarn to package being wound at a predetermined tension. Tension is entirely independent of the supply package and is controlled by setting a spring. In density control mechanism (below package) as pressure on package tends

to increase, pressure bar is permitted to fall away from package slightly through an escapement. Pressure is governed by small weights operating against friction on pressure bar: as friction increases on pressure bar, it turns slightly, releasing a ratchet which permits clock mechanism to run and pressure back to move slightly. Upon moving the back away for any reason, it is returned to its approximate position by pressure of hand. Then a rubber-covered wheel is used to turn the clockwork for precise adjustment. The combined automatic mechanisms enable a package of any reasonable density to be wound.—*Walter Kidde & Co., 88 West St., New York 6, N. Y.*

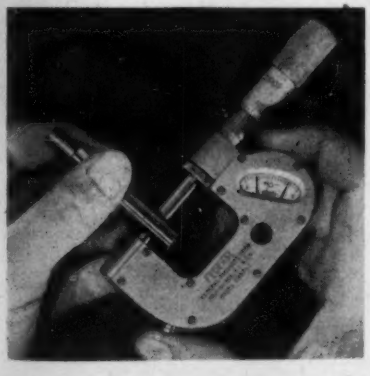
Fractional-hp. Motors

New "SP-37" and "SP-38" four-pole shaded pole fractional-hp. motors are especially suited for automatic timing

devices, drafts and damper controls, unit heaters and coolers, exhaust fans, remote control drives, etc. They are regularly wound for 115 volts, 60 cycle, single phase. Special voltages to order. Can be wound to stand locked rotor conditions continuously. Laminated field and rotor cores. Ball or oilless bearings. Available with or without fan blades, mounting brackets or bases. No switches, brushes, commutators, slip rings or capacitors. No radio interference.—*Small Motors, Inc., 1308 Elston Ave., Chicago 22, Ill.*

Micrometer with Dial Indicator

New "200-P-1 Indicating Micrometer" is said to mark the first radical improvement in micrometers since they

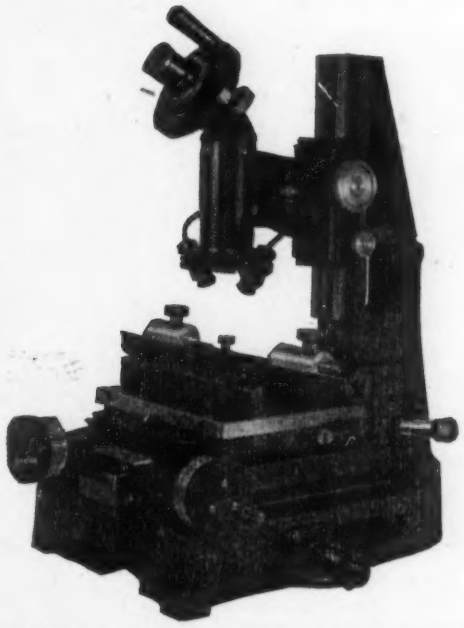


were originally made; and to combine the accuracy over the full one-inch of the micrometer screw, with the precision of the dial indicator. It can also be used as a dial indicator comparator without necessity of setting to a master: micrometer feature furnishes its own precision setting. In both uses, anvil pressure is constant and, therefore, real accuracy of instrument can be realized, independently of "feel." As a comparator a single micrometer can replace a complete series of ordinary go and no-go gages. Indicating dial is provided with tolerance hands which can be easily set with a wrench furnished with instrument. Micrometer scale and the indicating dial are graduated in 0.0001" and measuring capacity is 0-1". For use as a comparator, measuring spindle is locked in desired position and opposite anvil is retracted by pressure on the finger or thumb button. This enables workpiece to be inserted with less chance of anvils scratching it; also prevents excessive wear on anvils. Both contact faces are tungsten carbide tipped. Retracting mechanism operates separately from movement and cannot influence reading. — *Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Rotameter for Process Industries

New "Full-View Rotameter" is designed specially for accurate flow rate measurement and control under severe services and corrosive conditions encountered in the process industries. Design is based on simple square block and fittings, fastened together rigidly by heavy flat side plates. "Safety-Shielding" is obtained by front and

the **GAERTNER**



TOOLMAKER MICROSCOPE

for length, coordinate and angle measurements

direct to .0001" and 1 minute of arc

Widely used to inspect work in progress and finished work

To measure form tools, milling tools, drill jigs, templets and gauges, machine parts, taps and hobs.

To perform the various thread measurements.

An accurate, reliable and durable instrument incorporating fine machining and carefully adjusted optical parts.

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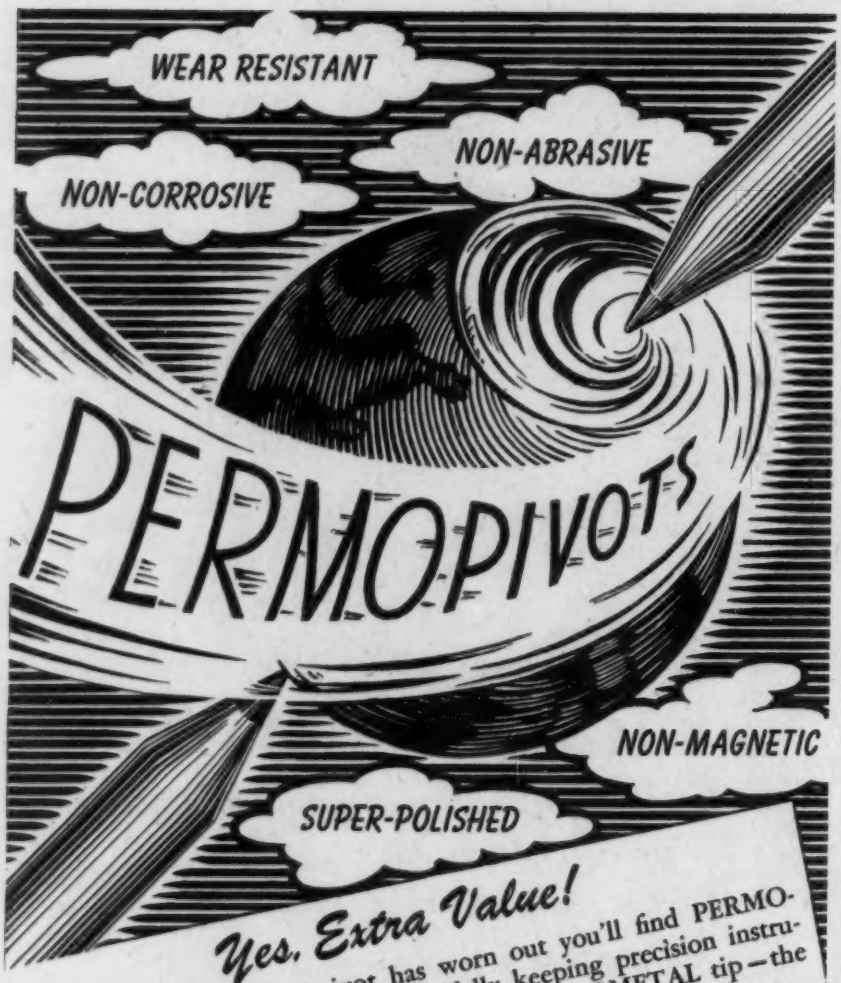

Yes, Extra Value!

Long after the ordinary pivot has worn out you'll find PERMOPIVOTS in the prime of life—faithfully keeping precision instruments precise! It's all due to the special PERMOMETAL tip—the ideal osmium alloy. . . . Made to your specifications.

Write for information!

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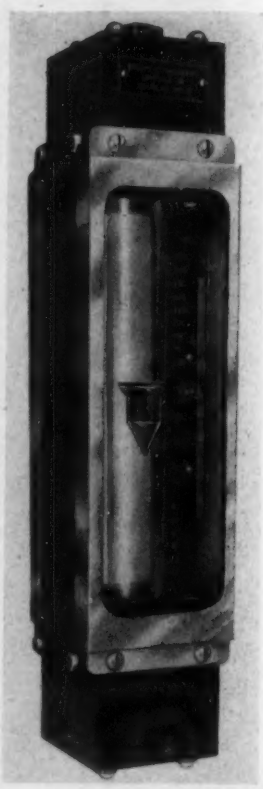
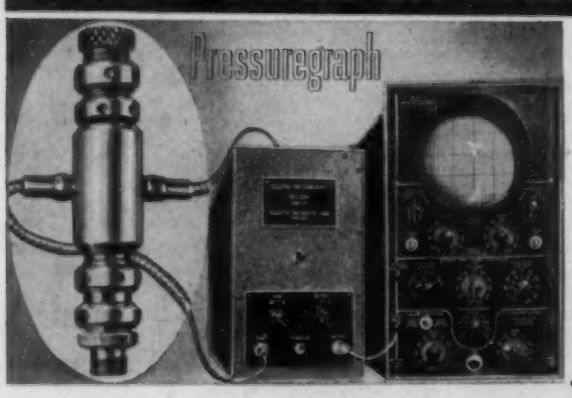


back safety glass windows, ¼" thick, held in place by stainless steel window frames 3/32" thick. All surfaces are gasketed to prevent leakage. "Full-View" rotameter is claimed to have many advantages "never before grouped in one flow rate instrument," among them: (1) interchangeable "Tru-Taper" precision metering tube; (2) wide space between side plates so that float position can be easily and accurately read, even from an angle; (3) metering tube easily replaced without taking instrument out of the line; (4) end fittings universal for connections in four directions, 90° apart; (5) square shape makes it easy to panel mount with simple, inexpensive right-angle brackets; (6) parts specified and treated to prevent external corrosion; all steel parts rust-proofed, all steel and brass parts given three coats of "Brookote" acid- and alkali-resisting finish, all bolts, nuts, screws, and dowels as well as front and back window frames, made of stainless steel; (7) "Safety-

NOW! For Accurate Pressure-Time-Curve Measurements



Indicates accurately in linear response, on screen of cathode ray oscillograph, the pressure-time-curve of any internal combustion engine, pump, airline, or other pressure system where pressure measurements are desired. Covers wide range of engine speeds and pressures up to 10,000 p.s.i. Screws into cylinder and can be calibrated using static pressures. Vibration-proof. Accurate, dependable for engine tests.

SIMPLE OPERATION—ONLY ONE CONTROL

In operation the pick-up section (enlarged at left) is inserted in cylinder, chamber of airline, etc. Pick-up has temperature compensation for all normal operating conditions. Successfully used for tests of injection pumps, diesel and automotive engines, explosives, oil pumps and air compressors.

For details address manufacturer

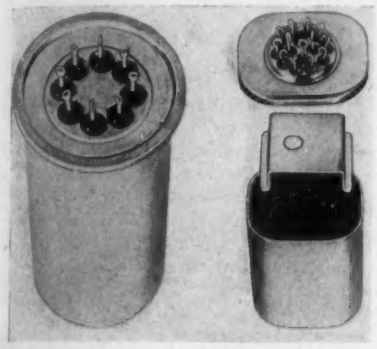
***Electro* Products Laboratories**

549 W. RANDOLPH ST., CHICAGO 6, ILLINOIS *Phone STAte 7444*

Shielded" leak-proof enclosure thoroughly protects operator and allows him to read meter with complete safety. "Full-View Rotameter" is available in sizes from ⅛" to 4" with screwed or flanged connections. With a metal tapered tube, it can be used for pressures as high as 600 lbs./in.^{2}. It is made in iron, brass, and stainless steel. All metal parts of brass meter are brass, and all metal parts of stainless steel meter are stainless steel. In addition, several special materials such as Hastelloy, aluminum, lead, hard rubber, etc. can be furnished. New rotameter can be obtained as a simple flow-rate indicator or with remote instrument for recording or recording-controlling-flow-rate. Flow totalization can also be included.—*Brooks Rotameter Co., Box B-125, Lansdale, Pa.*

Complete Enclosures for Electrical Components

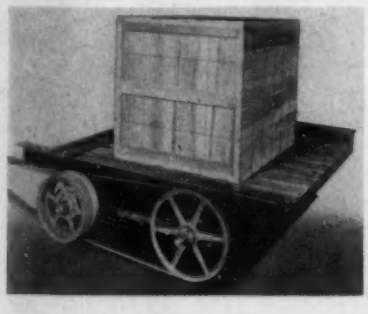
New line of enclosures for electrical components—relays, coils, transformers, etc.—consists of round or square



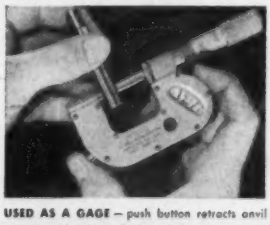
cans in lengths to 6" available with or without equipment-mounting bridges attached to can interior. Terminals are brought out through sealed headers in base. Headers can be supplied for plug-in use. Round cans have any number of contacts up to eight. Square cans have a maximum of fourteen leads. Units so housed are easily replaced or serviced. Complete protection is afforded from dust, dirt and moisture.—*Electrical Industries, Inc., 42 Sumner Ave., Newark 4, N. J.*

Vibration Test Table

New test table vibrates and shakes like a freight car, even to the pitch and toss, to test packages and products to be sure they will arrive in good condition. It is said that one hour's test will equal a coast-to-coast freight trip. Two eccentric shafts, one under each end of a strong table, cause the table to vibrate with a circular motion in a vertical plane, and with a displacement about the same as the maximum deflection of average freight car springs and at a frequency similar to their natural frequency. The shaft at one end of the table can run either synchronously or out of phase with the shaft at the other end, or at a different speed. As a result, the table has a mixed motion and a "pitch and toss" in addition to its vertical and horizontal movements. The rhythm is similar to freight cars. The package repeatedly bumps a fence secured to the table, giving it shocks similar to car bumping or train jerks. Smaller packages may be stacked or larger boxes strapped down to duplicate actual freight car loading methods used. Table size 5′× 5′. Capacity 1000 lbs.—*L. A. B. Corp., Union Place, Summit, N. J.*



USED AS A MICROMETER — spindle is brought into contact until Indicator reads "O".



USED AS A GAGE — push button retracts anvil and dimension is checked on dial.

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This new Federal Indicating Micrometer combines the precision of the Dial Indicator for uniformity of contact pressure and for use as a comparator, with the accuracy of the micrometer thread for measuring.

You do not need the skill of a toolmaker to operate it accurately. The Dial Indicator insures uniform contact pressure.

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Instrument Societies

INSTRUMENT SOCIETY OF AMERICA SPRING TECHNICAL SESSION

Plans have been completed for the Spring Technical Session of the Instrument Society of America to be held in Detroit at the Engineering Society of Detroit Building on Thursday April 4th. The session will open at 9:30 A. M. In the evening, a banquet meeting has been planned.

On Friday, April 5th, the meeting of the delegates of the various local sections will be held.

—RICHARD RIMBACH, *Secretary*

CHARLESTON

At the January 7 meeting of the Charleston (W. Va.) Section, Mr. E. I. Thomas of Carbide and Carbon Chemicals Corporation spoke on valve positioners. He defined them as "a simple air-operated, narrow-band proportional controller used for positioning pneumatically-operated diaphragm-motor valve stems, and overcoming dead spots caused by friction in the valve assembly, particularly the valve stuffing box."

Mr. Thomas pointed out that valve positioners are also used for operating two or more valves in sequence, for overcoming unbalance in single seat valves, and also as position transmitters. He stated that the first valve positioner was probably developed as a result of the Taylor Instrument Companies' Dubl-Response Unit. He showed slides and charts of the various characteristics of the devices and gave a very comprehensive analysis of them.

The newly elected officers are: *President*, Charles B. Cochran (Westvaco Chlorine Products); *Vice President*, Earl A. Bryant (duPont); *Treasurer*, Frank J. Sercelj (duPont); *Secretary*, Marvin B. Lorig (Carbide & Carbon); *Executive Committee*, E. R. Myers (duPont), Charles Holz (Industrial Equip. Co.), William Warner (Carbide & Carbon), Louis Keppler (Virginia Gas & Oil), John T. Ward (U. S. Rubber) and the officers.

—M. B. LORIG, *Secretary*

DETROIT

At a business meeting of the Instrument Society of Detroit on January 21, plans were consummated for the National Society technical meeting which will consist of a technical conference during the day and evening of April 4 and a business meeting of I. S. A. delegates on April 5 and 6. At this time the Instrument Society of Wayne County and the Instrument Society of Detroit will act as joint hosts to the Instrument Society of America. This technical session will be held at the Rackham Memorial Building and will last a period of 3 days.

The Executive Committee was authorized to prepare a recommendation for presentation to the membership on joining the Instrument Society of America. After an enthusiastic discussion on this subject, the meeting was adjourned.

—J. MCCULLOUGH, *Secretary*

NORTH INDIANA

The Northern Indiana Section of the Instrument Society of America held its January meeting on the evening of January 18, at the Lake Hotel in Gary, Indiana.

After the dinner a short business meeting was held in which president Kenneth Frame informed us of I.S.A. activity in behalf of the bill now before Congress, which is designed to conserve American scientific personnel. The bill was read to the members and a motion was made and passed instructing corresponding secretary Charles Haynes to write to the proper Congressmen that the Northern Indiana Section of the Instrument Society of America is in favor of the passage of this bill.

Program chairman William Hitt gave us a preview of the next two meetings.

The meeting was then turned over to Mr. Carl Hayden of the Askania Regulator Co., who spoke in place of Mr. Proy of the same firm, who could not be with us. Mr. Hayden prefaced his talk with a discussion of A.S.M.E. instrument terminology, which he illustrated with blackboard. He followed this with a talk on Askania hydraulic and pneumatic control which was illustrated with slides. It was a most informative talk on a subject which was new to some of us. Mr. Hayden was plied with many questions throughout his talk, attesting to the interest he created.

—EDWARD WHITE, *Publicity Chairman*

PITTSBURGH

The Pittsburgh Section of the Instrument Society of America held the January meeting on the 28th at the Roosevelt Hotel. Forty members and guests were present for the excellent dinner and sixty-five for the meeting and lecture.

Dr. E. R. Schaeffer, of the Science and Technology Division of the State Department, spoke interestingly and briefly on his observations, with particular reference to instrumentation, during his post-war travels in Germany.

The scheduled speaker of the evening, Mr. Walter T. Buhl, of the Jack and Heintz Co., described captured German gyro instruments. He described briefly, and illustrated with slides, applications and circuits in which these gyros were used to control the V-1 robombs, and the V-2 rocket bombs, airplanes, and for marine use. He pointed out a number of unusual and ingenious methods which were used by the Germans in accomplishing the end result.

Mr. Buhl also placed on exhibition several captured gyro instruments and controllers. The precision, delicacy, fine workmanship and clever engineering applications commanded the admiration of all who could appreciate fine instruments, even though made by an enemy.

However, lest his listeners underrate U. S. and Allied equipment relative to Germany's, Mr. Buhl pointed out that Germany lost the war. He further mentioned that three months after the first robomb fell on London the U.S. had a similar robomb available for trial and the fifth one tried flew so successfully that it had to be shot down.

—LESTER F. BOSS

SOUTH TEXAS

The South Texas Instrument Society has been organized in the territory surrounding Corpus Christi, Texas. Affiliation with the Instrument Society of America as a section is planned in the near future. Meetings are held the second Tuesday of each month.

At previous meetings, members from the U.S. Naval Air Station at Corpus Christi gave interesting talks on automatic airplane pilots, gun sights, and navigation; also, Mr. Allegret of Schlumberger Oil Well Surveying Corp. gave an illustrated lecture on Electric Well Logging.

Current officers are J. G. Pratt, President; H. C. Givens, Secretary; V. J. Brunson, Treasurer.

Anyone interested in control and measuring instruments is cordially invited to attend the meetings and become a member.

—H. C. GIVENS, *Secretary*

PHILADELPHIA

The Philadelphia Section met January 16th at the Broadwood Hotel. Newly elected president, John Johnston, Jr. (Sun Oil Co.) presided. The other new officers elected at the December meeting are as follows: F. H. Trapnell (du Pont) Vice-President; J. C. Whiddett (Automatic Temperature Controls Co.) Treasurer; C. W. Wood (Mason-Neilan) Secretary.

Mr. John Coffeen, President of the Ess Specialty Corp., delivered a talk on "Phototubes in Industrial Instruments." He covered early developments, some phototube theory, and went on to show that in many applications, phototube devices enjoy definite advantages in having extremely high sensitivity and no time lag. Some of the applications mentioned were: Analysis of a four-component metal alloy merely by a phototube scanning of a sample piece, indication of turbidity of liquids, color matching, and detection of hydrocarbons.

Mr. Coffeen called on Ray Heimsoth, his chief engineer, who very ably cov-

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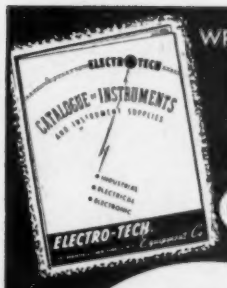

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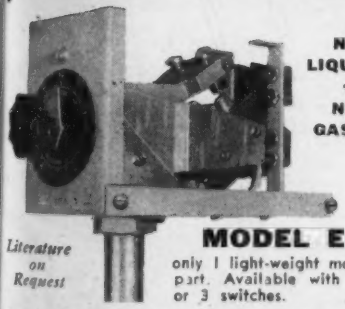

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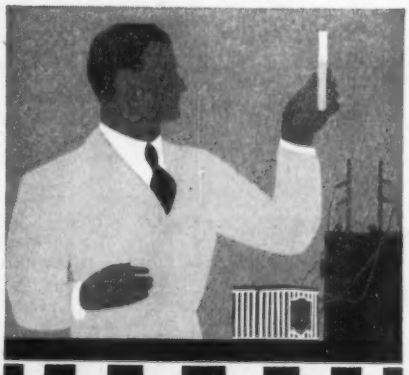

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INSTRUMENT SOCIETIES CALENDAR

City, Society, and Secretary	Date and Place	Subject and Speaker
Akron, Ohio; Akron Instrument Society		
Atlanta, Ga.; Georgia Society for Measurement and Control, John Roberts	**Feb. 25**(A), Blue Flame Room, Atlanta Gas Light Co.	"Theory and Application of Flowmeters," M. F. Merl
Baltimore, Md.; Baltimore Industrial Instrumentation Society; P. Ragan, Fuel Div., Beth. Steel, Sparrows Pt., Md.	Engineers Club, 6 W. Fayette St.	
Charleston, W. Va.; Charleston Section, I.S.A.; M. B. Lorig, 1506 Virginia St., Charleston 1	**Mar. 4**(B), Ruffner Hotel **Apr. 1**(B), Same **May 6**(B), Same	"Boiler Control," M. J. Boho, Hagan Corp. "Control Valves," Bruce Irwin, Hammel-Dahl "Pneumatic Transmission and Control," W. B. Heinze, Cochrane Corp.
Chicago, Ill.; Chicago Section, I.S.A.; A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago	**Mar. 4**(B), To be announced **Apr. 1**(B), To be announced **May 6**(B), To be announced	"Application of Valves in Automatic Control," C. R. Mason, Bristol Co. "New Optical Tools," J. W. Forrest, Bausch & Lomb "New Electronic Measuring Instruments," W. Mikelson, General Electric
Cleveland, Ohio; Cleveland Instrumentation Society; A. J. McCullough, Minneapolis-Honeywell, 1005 Euclid Ave., Cleveland 3	**Feb. 27**(B), Cleveland Engineering Soc.	"Pneumatic Null Balance," C. B. Moore, Moore Products
Detroit, Mich.; Instrument Society of Detroit; J. McCullough, 870 Seward St., Detroit 2	**Feb. 18,** Ethyl Research Lab. **Mar. 18,** Same **Apr. 4,** Rackham Memorial Bldg. **Apr. 5 & 6,** Same	"Force Measurement," M. Yeasting, Toledo Scale To be announced Technical Conference; List of technical papers will be announced I.S.A. Delegates Business Meeting
Florence, Ala.; Muscle Shoals Instrument Society; J. W. Moffett, 323 E. Mobile St., Florence		
Ft. Worth, Tex.; Ft. Worth Electronics Club; W. H. Farrington	**Feb. 21**(A), Texas Hotel	"Electronic Positioning," R. H. Wicklund
Gulf Coast (Tex.); Gulf Coast Section, I.S.A.; O. D. Sanders, Neches Butane Co.	**Feb. 19,** Inst. Lecture Room, Lamar College, Vocational Section	Round table discussion of special instrumentation problems
Hartford, Conn.; Hartford Society for Measurement & Control; Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.	**Feb. 19**(B), Bond Hotel **Mar. 19**(B), Same **Apr. 16**(B), Same **May 21**(B), Same	"Use of Air in Gaging," R. Y. Moss, Sheffield Corp. "Electron Microscope," R. B. Barnes, C. J. Burton, Amer. Cyanamid "Comparison of Materials for Gages," H. O. Richter, W. R. Moore, Norton Co. Annual Business Meeting
Houston, Tex.; Houston Instrument Society; O. W. Muller, 1536 Mellie Esperson Bldg., Houston 2		
Indianapolis, Ind.; Indianapolis Technical Instrument Society; Morris Underwood, Indianapolis Power & Light Co., Indianapolis 6	**Mar. 3,** Purdue University Center **Apr. 2,** Same	"Diaphragms and Control Valves," P. A. Elfers, Fisher Governor "Recording Instruments," R. J. Kryter, Esterline-Angus
Kansas City, Mo.; Kansas City Section, I.S.A.; O. L. Boutros, 1627 E. 31st St., Kansas City 3		
Los Angeles, Calif.; California Section, I.S.A.; M. D. Pugh, 35 S. Raymond Ave., Pasadena 1	**Mar. 5**(B), Eaton's Ardmore Cafe **Apr. 2**(B), Same **May 7**(B), Same **June 4**(B), Same	To be announced To be announced To be announced To be announced
Newark, N. J.; Society for Measurement & Control (N. J.); H. S. Close, 831 Dixie La., Plainfield, N. J.	**Mar. 5**(B), Essex House **Apr. 2**(B), Same	"Combustion Control," Harry R. Kessler, Republic Flow Meter "Thermocouple Method of Temp. Meas.," V. L. Parsegian, Tagliabue
New Orleans, La.; New Orleans Instrument Society; W. H. Haney, 1016 Esplanade Ave., New Orleans	St. Charles Hotel	
New York, N. Y.; New York Section, I.S.A.; C. D. Corey, Riebor Research Lab., 127 E. 73rd St., New York 21	**Feb. 25**(B), Faculty Club, 400 W. 117th St.	"Automatic Control—Servomechanisms," L. A. MacColl, Bell Tel. Labs.
N. Indiana; Northern Indiana Section, I.S.A.; C. P. Hayes, Red River Oil Ref., 935 177th Pl., Hammond, Ind.	**Feb. 15**(B), Lake Hotel, Gary **Mar. 15**(B), Same	"A Trip Through an Inst. Mfg. Plant," Joseph Connelly, Foxboro "Electronics," Theodore Cohn, Taco Eng. Co.
Philadelphia, Pa.; Philadelphia Section, I.S.A.; Clarence W. Wood, Mason-Neilan, 6908 Market St., Upper Darby, Pa.	**Feb. 20**(B), Broadwood Hotel	"Flow Meter Problems," Wm. Bennett, Cochrane Corp.
Pittsburgh, Pa.; Pittsburgh Section, I.S.A.; L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	**Feb. 25**(B), Roosevelt Hotel **Mar. 25**(B), Same **Apr. 22**(B), Same **May 27**(B), Same	"Fractionating Column Control," Lyman H. Allen, Jr., Amer. Viscose Corp. "Inst. Maintenance in Oil Refinery," M. H. White, Atlantic Ref. Co. "Control Valve Characteristics," R. Rockwell, Mason-Neilan "Fractional H-p. Motors," C. G. Veinott, Westinghouse
St. Louis, Mo.; St. Louis Society for Instrumentation; Gus Holubeck, Union Electric Co., Venice, Ill.	York Hotel	
Sarnia, Ont., Canada; Sarnia Instrument Association; K. Williamson, 168 Cobden St., Sarnia	**Feb. 15**(A), St. George's Hall	"Rotameters," K. Fischer, Fischer & Porter
Southwest Texas; South Texas Instrument Society; Homer C. Givens, LaGloria Corp., Falfurrias, Tex.		
Kingsport, Tenn.; Tennessee Section, I.S.A.; C. F. Palmer, 2924 J. C. Hwy., Kingsport	**Mar. 13**(C), Kingsport Inn **Apr. 10**(C), Same	"Flow Metering," J. B. McMahon, Republic Flow Meters "Electrical Instruments," L. P. Parachini, Weston
Toronto, Ont., Canada; Ontario Section, I.S.A.; T. C. Agnew, Minneapolis-Honeywell	**Feb. 21**(B), Chez Paree Rest. **Apr. 18**(B), Same	"Instrumentation of Fluid Catalytic Cracking Plant," V. V. Tivy, Foxboro "Instrumentation in Glass Industry," W. O. Fleming, Corning Glass (Canada)
Washington, D. C.; Washington Section, I.S.A.	**Feb. 26**(D), Interior Dept. Auditorium	"Behind the Instrument Dial," L. F. Parachini, Weston
Whiting, Ind.; Whiting Instrument Men's Guild; Lloyd Clouse, 7344 Dante Ave., Chicago 19, Ill.		
Wyandotte, Mich.; Instrument Society of Wayne County; Chas. Chessroom, P.O. Box 150, Wyandotte	**Feb. 25**(B), Presbyterian Church Hall	Forum on Control Systems, Messrs. Lupton, Gambrill, Webb

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

ered the Ess Photoelectric CO_2 Indicator with the aid of a demonstrating unit. He also mentioned Ess Photoelectric liquid turbidity indicating equipment which is sensitive to 2 parts per million, 5 p.p.m. being beyond the sensitivity of the human eye.

—J. J. FREGEAU,
Publicity Committee Chairman

LOS ANGELES

At the annual meeting of the California Section of the Instrument Society of America held Tuesday evening, January 8th, the following officers were elected for 1946: *President*, Howard H. Cary (National Technical Laboratories); *Vice-President*, Richard P. Gallien (R. P. Gallien Co.); *Secretary*, Milo D. Pugh (Instruments Publishing Co.); *Treasurer*, F. H. Cole (Cole Instrument Co.); *Councillors*, Fred C. Henson (Fred C. Henson Co.) and Robert W. Fulwider, Patent Attorney.

Following the business meeting a film was shown by Gillfillan Bros. which covered the story of radar and its use in war and peacetime flying. This was presented by courtesy of the Army Air Force and particularly featured the use of radar for Ground Approach Control for aircraft. Mr. A. P. Albrecht, Chief Field Engineer of Gillfillan Bros., further explained the development and use of radar for landing aircraft in any kind of weather.

Fifty-two attended the dinner with about sixty-five for the meeting.

—M. D. PUGH, *Secretary*

NEWARK

At the January 8 meeting of the Society for Measurement and Control (New Jersey) the general topic of flowmetering was discussed, with special reference to sources of error and the manner in which the error enters into the final result. Mr. L. K. Spink was the speaker of the evening and evidenced his familiarity with the subject by covering it in considerable detail. Mr. Spink's experience in the field and his background of addressing several other Instrument Societies was evident throughout the discussion.

The question period brought out several interesting points which indicated that basic flow data are still insufficient for industry needs in the general regions of pulsation, eccentricity, and straight pipe requirements.

—H. F. MOORE, *President*

WYANDOTTE

The Instrument Society of Wayne County had a large attendance at the January 28 meeting and there were a number of applications for membership. Our present meeting place is well located, roomy and we expect to grow.

The talk on Venturi Meters by Mr. M. M. Borden of the Simplex Meter Co. was out of the ordinary and very welcome. It was well illustrated by slides showing details of construction, checking and accuracy, and large or unusual installations. We were interested in the history and development of metering and in Mr. Borden's reminiscences.

—JOHN MACPHERSON, *Vice President*

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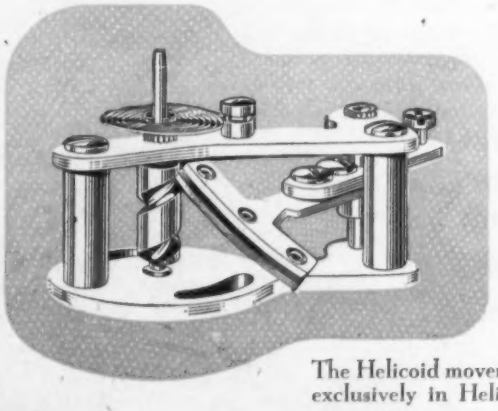

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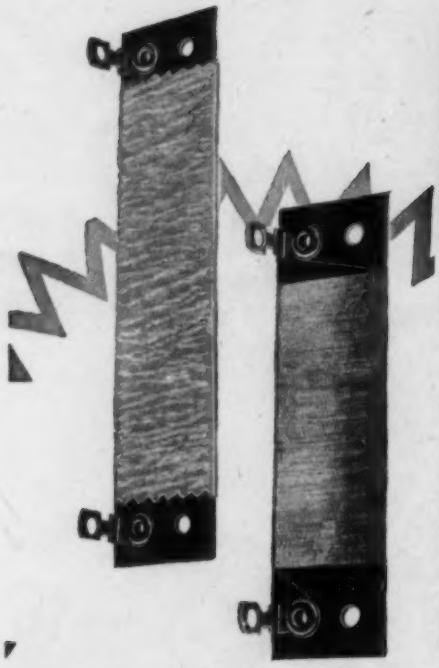

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Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card inside the back cover.

N-33 Crank Type Cylinders for Controlling. 4-page 8½" × 11" Bulletin 126 pictures and describes various crank-types cylinders that are said to reduce wear on shaft and packing, virtually eliminating oil leakage and protect against dirt and corrosion. Booklet covers the adjustment of angular travel of crank for desired stroke and power and compensation for non-linear flow characteristic of butterfly valves. Askania Regulator Co., 1603 S. Michigan Ave., Chicago 6, Ill.

N-34 Electronic Switch. 2-page 8½" × 11" Page 104, Filing No. 6926, pictures and describes "Type YE-9" electronic switch used for special electrical studies of wave form, phase, frequency relationship and for comparison of amplitude. General Electric Electronic Division, Syracuse, New York.

N-35 "Rotasleeve Dimensions." Single-sheet 8½" × 11" Bulletin 83-A gives tabular information on new "Rotasleeve" (see item N-7 above). Fischer & Porter Co., Hatboro, Penna.

N-36 "The Burrell Technical Announcer." 24-page 7½" × 8½" issue No. 45-9-20 of this house organ features illustrated articles entitled "The Tool of Thought" and "The Making of Nylon." Described and pictured also are the following mechanisms: dielectric type moisture meter, duo-seal vacuum pumps, Taylor poly phosphate comparator, microscope illuminator, sodium radiator, and multiple unit furnaces. Burrell Technical Supply Co., 1936-42 Fifth Avenue, Pittsburgh 19, Pa.

N-37 Vibration Test Machine. 6-page 8½" ×11" bulletin pictures and describes "Type VU-DM-100" three-dimensional vibration testing machine said to enable manufacturer to make a thorough study of performance and endurance of a new product under actual conditions of mechanical vibration. L.A.B. Corp., Summit, N. J.

N-38 "Reco" Thermatic Flashers. 4-page 8½" × 11" Bulletin No. 62 pictures and describes "Reco Skedoodle Flashers," a devolpment in motorless thermoflasher that controls a relay, handling one or two circuits on off, or alternately. Reynolds Electric Co., 2650 W. Congress St., Chicago, Illinois.

N-39 "Electronic Pneumatic Mechanical Instrumentation." 32-page 8½" ×11" October-November issue of this house organ (designated as Vol. 1, No. 6) features the following illustrated articles: "The Thin Plate Orifice for Measurement of Fluids" by Louis Gess and R. D. Irwin, "Process Quality Control with X-ray Spectrometer" by J. S. Buhler, "Pneumatic Spring and Diaphragm Motors" by R. B. Werey, "Control of Recuperative and Direct Fired Soaking Pits" by J. P. Vollrath, "Electronic Measurement of Moisture in Paper" by D. C. Culver, "Liquid Level Measurement in Open Vessels" by C. F. Cusik and R. E. Jones and "Oil Refinery Instrument Maintenance" by Alfred Krieg. Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Wayne and Roberts Aves., Phila. 44, Pa.

N-40 "The Hagan Thrustorq." 4-page 8½" × 11" Bulletin No. 9345 pictures and describes an air-operated torque measuring device for engine horsepower applicable to aviation and automotive fields. Principle of operation, features and available designs, notations on, How to choose proper size are all summarized. Thrustorq Div., Hagan Corp., Hagan Bldg., Pittsburgh, Pa.

N-41 Oil Vapor Vacuum Pump. 4-page 5½" × 8" brochure pictures and describes an all-metal oil vapor vacuum pump said to be successfully used in vacuum-tube plants. Included also are the physical and operation data, standard equipment listing, and a list of accessories available. Litton Engineering Laboratories, P. O. Box 749, Redwood City, Calif.

N-42 Air and Hydraulic Cylinders. 4-page 8½" × 11" Bulletin A-103 describes new line of air and hydraulic cylinders. The 200-lb. pressure air cylinders are described as having steel heads and caps and brass cylinder walls, and the 1500-lb. pressure hydraulic cylinders, as having solid steel heads, caps and walls. Included also are a series of sketches giving mounting information. Miller Motor Co., 4027-33 No. Kedzie Ave., Chicago 18, Ill.

N-43 "Facts Behind Production." 4-page 8½" × 11" folder features the "Simplex Productograph," which automatically records stops on printed tape. It is described as being capable of taking care of seven secondary units, and prints hours either in conventional 1 to 12 noon, 1 to 12 midnight, or continental time (24-hr.). Sample of tape records and tape symbol interpretation are included. Simplex Time Recorder Co., Gardner, Mass.

N-44 Feed Systems for Boiler Water Treatments. 4-page 8½" × 11" Bulletin No. 451 describes two methods for chemically treating boiler water. Also

described and schematically illustrated are two complete pump units, which includes solution tanks. Milton Roy Pumps, 1300 E. Mermaid Ave., Chestnut Hill, Phila. 18, Pa.

N-45 **Precision Levels.** 4-page 8½" × 11" folder pictures and describes an "All-way" precision level that indicates level of all ways at once when leveling any machine. The folder gives the specifications of the two sizes manufactured and accuracy possible with each. Wm. B. Fell Co. Mfg., 700 S. St., Rockford, Ill.

N-46 **"Vergilio News."** 16-page 8½" × 11" issue of this house organ (designated as Vol. 6, No. 1) features the following articles: (1) Steam Production at Cudahy, (2) Mass Action Soot Blowers, (3) Simplified Determination of Flow-meter Range (4) How Draft is Measured, and (5) Adapting Automatic Combustion Control to Spreader Stokers. These articles are accompanied by illustrative diagrams, and tables. J. L. Vergilio Co., Cleveland, Ohio.

N-47 **"Catalog of Instruments and Instrument Supplies."** 28-page 8½" × 11" catalog lists, pictures and describes a number of industrial, electrical and electronic instruments carried in stock. Electro-Tech Equipment Co., 119 Lafayette St., New York 13, N. Y.

N-48 **"Super Sight."** 6-page 3½" × 4½" pamphlet pictures several types of magnifying lenses used for industrial first aid and laboratory purposes, that have a magnifying lens, 4" or 5" dia. and light en-unit that can be moved around. The Boyer-Campbell Co., 6540 St. Antoine St., Detroit 2, Mich.

N-49 **Precision Measuring Instruments.** 4-page 8½"×11" folder pictures and describes the "Amic" comparator designed for convenient and quick checking of components without eye fatigue. Feature is pointer movement of one full inch on 6" scale for a 0.001" displacement of measuring pin. Accessories for measuring hollow pin or between centers, special anvils, etc. are also illustrated. American Measuring Instrument Corp., 240 West 40th St., New York, N. Y.

N-50 **Tachometers.** 4-page 8½"×11" bulletin illustrates and describes several tachometers suitable for industrial r.p.m. or surface-speed measurements. Units for permanent and portable installations are catalogued. Chicago Electric Tachometer Co., 800 North Clark St., Chicago 10, Illinois.

N-51 **Humidity Control.** 4-page 8½" ×11" bulletin pictures and describes a new method of humidity control. Instrument is electrically operated and only moving part is a relay used to operate the humidifiers. Detecting element is held under a slight constant tension and measures electrically. Norcross Laboratories, Watertown 72, Massachusetts.

N-52 **"Jim's Adventure."** 20-page 8½"×11" comic book explains how electricity is generated and distributed. The narrative is about an educational trip taken by a small boy and his uncle. They visit a steam generating plant, follow the electric power lines from the station back to the boy's home and, in the end, the uncle explains to the boy how electricity is metered. A two-page drawing outlines the basic steps in steam and electricity generation and power distribution, from boiler to light switch. A brief glossary of common electrical terms is also given. Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin.

N-53 **Spectrographic Equipment.** 16-page 8½"×11" catalog describes and illustrates spectrographic equipment for research and for analysis in metallurgy, mineralogy, agronomy, chemistry, medicine and other fields. Theory and use of the spectrograph are outlined. Catalog shows how company carries in stock a complete assortment of books, spectrum prints and charts, also reprints from the literature covering all aspects of spectroscopy and its applications. Jarrell-Ash Company, 165 Newbury St., Boston 16, Massachusetts.

N-54 **"Cenco News Chats."** 18 page 8½"×11" Issue No. 50 of this house organ features an article on Dr. Theobald Smith, an American bacteriologist whose work on the nature and causation of infection and parasitic diseases opened many new fields for research. Other articles and sections are: "Research in Action" describing the work of the Battelle Memorial Institute; "Technical Events and Abstracts"; "Speeds Oxygen Determination in Steel"; "Spot Plates Promote Sanitation" and "The Laboratory Assistant," a section covering new ideas for better work. Central Scientific Company, 1700 Irving Park Road, Chicago 13, Illinois.

N-55 **Industrial X-ray Equipment.** 12-page 8½"×11" booklet describes and illustrates x-ray equipment for fluoroscopy, radiography, diffraction and spectrometry. Text covers: (1) Model 80 and 150 with description and specifications, radiograph illustrations showing x-ray application, and inches penetration chart; (2) Model 150 CF conveyor type; (3) Model 90 mobile unit; (4) x-ray spectrometer and camera type x-ray diffraction unit, and (5) convenient application chart. North American Philips Co., 100 E. 42nd St., New York 17, N. Y.

N-56 **"Precise Production."** 4-page 8½"×11" issue No. 111 of this house organ features the new Scherr gage block utility set and also shows a ball-joint back indicator set with magnetic base for speeding dial indicator set-ups. George Scherr Co., 200 Lafayette St., New York 12, N. Y.

N-57 **Level-Buoy Indicating Controller.** 8-page 8½"×11" bulletin describes the purpose, construction and operation of this instrument in which pointer indication of level is entirely mechanical and independent of controller air supply. Taylor Instrument Companies, P. O. Box 110, Rochester 1, New York.

N-58 **Aneroid Manostat.** 2-page 8½" ×11" bulletin describes and pictures this instrument for maintaining vacuum or pressure systems at set pressure. Two ranges are available—one for vacuum systems only and the other for both vacuum and pressure systems. Both are for laboratory and industry calibration and testing of pressure instruments, high-vacuum distillation and vacuum-tube production and research.

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N-59 Piezo-electric Crystals. 20-page 8½"×11" catalog describes numerous types of crystals for amateur, experimenter, transmitter and receiver manufacturers' needs. Special attention is given to a new compact type designed for commercial transmitters or receivers where space is at a minimum. Air-eon Manufacturing Corporation, Kansas City, Missouri.

N-60 Automatic Ballast-regulating Tube. 4-page 8½"×11" bulletin pictures and describes an automatic rheostat designed to keep the current in a circuit at a definite value. Should the supply voltage increase, the "Amperite" will increase in resistance to keep load voltage constant. Hook-up diagrams, charts and typical problems assist in undertaking the function of the tube. Tubes may be operated in parallel or in series. Amperite Company, 561 Broadway, New York, N. Y.

N-61 Silver Electrode Ceramic Capacitor. 4-page 8½"×11" bulletin describes the characteristics of "Hi Q" silver electrode ceramic capacitors with particular reference to the CI type with axial leads. Diagrams show construction and photographs illustrate various steps of manufacture and tests. Complete specifications and capacitance values are included, together with type designations according to JAN specifications. Electrical Reactance Corporation, Franklinville, New York.

N-62 Ultraviolet Fluorescent Rays. Folder contains ten 8½"×11" bulletins on fluorescent analysis with ultraviolet rays: (1) Fluorochemistry; (2) Fluorochemistry in petroleum science; (3) Ultraviolet light in criminology; (4) The ultraviolet lamp in scientific research; (5) Ultraviolet lights as an aid to education; (6) Fluorobiology; (7) Fluorochemistry in food science; (8) Ultraviolet light in detection of mercury; (9) Ultraviolet light in uranium prospecting; (10) Luminescence in gem science. Ultraviolet Products, Inc., 5205 Santa Monica Blvd., Los Angeles 27, Calif.

N-63 "Synchro-Lectric" Viscosimeter. 4-page 8½"×11" bulletin describes and pictures a viscosimeter adaptable to both laboratory and factory control work. Sub-headings of the text cover adjustments, determinations, results in absolute viscosity units, range, the models for practically every application, determinations of non-Newtonian behavior, accuracy, portability, operation, cleaning and care. Brookfield Engineering Laboratories, Sharon, Massachusetts.

N-64 "The General Radio Experimenter." 8-page issue, Vol. XX, No. 5 of this house organ contains two feature articles: (1) A wavemeter for 240 to 1200 megacycles and (2) a light source for microsecond photography. General Radio Company, 275 Massachusetts Ave., Cambridge 39, Mass.

N-65 Instruments for Refrigeration. 36-page 8½"×11" Catalog No. 300 on application of control instruments to the refrigeration field is divided into two sections, one covering applications, the other instruments. Taylor Instrument Companies, Rochester 1, N. Y.

N-66 "Apparatus Headliners." 4-page 8½"×11" bulletin for scientific laboratories covers conditioning ovens, drying ovens and sterilizers, for moisture tests, evaporating, drying, sterilizing, conditioning, rubber aging, plastic heating, lacquer baking, annealing and heat treating as required by A.S.T.M. and Government specifications. Boder Scientific Company, Pittsburgh 20, Pa.

N-67 Precision Levels. 2-page 8½"×11" bulletin pictures and describes the "All-Way" precision level and the "Fell" list indicator. The precision level, graduated in 0.0005" to the foot, is designed for machine tool manufacture or maintenance. The list indicator, for large floating dry docks, is a government specification to aid in keeping craft at a safe working level. Wm. B. Fell Company, 1401 Preston St., Rockford, Ill.

N-68 Engineering Instruments. 90-page 6"×9" catalog describes and pictures photographically the engineering instruments of this company's manufacture. Under transits are listed the Hell Gate engineers transit, mountain and mining Hell Gate transit, standard precise transit, reconnaissance precise transit, contractors and architects transit. Also listed are engineers levels, topographic instruments and equipment, hydraulic measuring instruments (current meters, water level recorders, field supplies), wind instruments and bore inspection telescopes. W. & L. E. Gurley, Troy, N. Y.

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